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Papers on Hydraulic Engineering. By SAMUEL MCELROY, C. E.

(Continued from page 298.)

No. 4.—CITY SEWERAGE. (Continued.)

Ancient and Modern Practice.—The discussion of the general characteristics of the disposal of sewage, as to street dirt, house sewage, rainfall, analysis of sewage, value, utilization, and sanitary results, having been made, we may notice rapidly the former and more recent methods adopted for such disposal, as a commentary of example and precept; following in this respect the engineering law which always settles the *modus operandi*, from the premises of what is to be done, and what has been done.

Ancient Practice.—In the Eastern Hemisphere the excellence of construction which characterizes the palmy days of the Roman Empire, may be taken as an example of former times. The authorities of Rome, clothed with great executive powers, magnified the calling of the engineers of the empire, and the engineers made the empire successful and glorious in public works, which testify to this day the science and art of their originators.

The examples of cities, harbors, roads, bridges, aqueducts, baths, sewers, and other works, which marked the progress of Roman conquest from Northern Europe to Africa, and from Spain, far beyond the Dardanelles, many of which are in use or in preservation at this

day, furnish lessons and laws of construction, which are full of interest to the artificers of national works at the present day; and among the ruins of the ancient city itself are hidden vital elements of engineering success, though they are covered with the *debris* of intervening centuries.

The sanitary care of public health at Rome and in many of the provinces was exercised to a singular extent, as compared with modern life. No house was tenable without its water supply, and the quality of this supply was rigidly studied; among the wealthy classes, the utmost range of luxury in private fountains, baths, and other means of comfort was known, and the vast extent and costliness of public sanitary works make a prominent feature in the history of the empire. In founding cities careful attention was paid to the health of the residents in the vicinity, to the prevalent winds, the action of the atmosphere on building stone, and the facilities for urban and suburban drainage. In one case, at *Salopia*, an entire city was removed four miles to improve its healthfulness of location, by vote of the Roman Senate.

For the distributing towers or *castellæ* of the several aqueducts, the baths, the places of public amusement, as well as the dwellings and streets, the most ample and particular provision was made for drainage, by the use of channeled stone-work, pipes, and main sewers. The pipes were made of copper, lead, terra cotta, and earthenware, with a free use of hydraulic cement mortar, pear-shaped, square, and circular in form, with different kinds of joints; for the sewers, peperino stone, of volcanic origin, was much used, on account of its hardness; for the street entrances marble was used, as at the Forum. The drainage of various lakes and marshes was also accomplished by works of great magnitude and cost.

In the *Coliseum*, ample provision was made by sewers connected with the *Cloaca Maxima*, to carry off the surface rain and the supplies from the urinals and other public conveniences. The drain of the third corridor, 17 ins. wide by 36 deep, is lined with tiles and coated with cement, taking the discharge from upright pipes built in the upper walls; all the corridor drains connect with the sewers under the arena. Fifty-six pipe drains, 12 inches in diameter, were provided for the third and fourth precincts, and all the mason work of the sewers, which still remain, is of the most careful kind, to prevent leakage and smell. Equally studied details are found in the theatres and amphitheatres in other parts of the empire.

The *Cloaca Maxima* of Rome, said to have been built in the time of the kings, and now filled up by the obstructions in the Tiber, is about 14 feet wide by 32 feet high, arched over. It drained the Forum and the public dwellings. Another sewer of equal dimensions under the Cornitium and Forum was discovered in 1742, about 40 palms below the present surface. But the entire network of sewers of the ancient city, now buried under the accumulations of centuries, failing to act, the new city is deprived of their use, and proverbially unhealthy. Rome, modernized, presents a type of many modern sanitary works. The

drainage of Lake Albano, undertaken 398 years before Christ, is one of the most remarkable works of the kind in existence.

The sewers of the Lazaretto at Genoa are supplied with a cleansing stream of water, conducted from the neighboring mountains, and carried through the court of the main edifice.

Earthenware pipes are found in the Egyptian tombs, in use as ventilators, and were used for other purposes in the prominent cities of that country. The use of concrete masonry in the pyramids, is an indication of the early application of hydraulic cement, which bears a most important part in the cisterns, aqueducts, sewers, and other hydraulic works of past and present ages; and the ruins of Carthage and Alexandria testify of the advanced state of these cities in sanitary works.

The public buildings, water-works, and sewers of *Agrigentum*, a Grecian colony, executed by Pheaces, 500 years before Christ, are recorded, as meriting special commendation, among the works of art in Sicily; while from the want of proper suburban drainage, *Pæstum* was abandoned by its inhabitants. *Aulis*, also a Grecian city, was celebrated for its manufacture of pottery. In the cities of Etruria, there are noted remains of arched passages which served as sewage outlets; some of these, as at *Tusculum*, show elaborate workmanship and ample proportions.

Recent explorations of the subterranean topography of *Jerusalem* have been made by Signor Pierotti, resulting in the confirmation of the history of Josephus, and a distinct tracing of the several ages of construction from Solomon to the Crusaders. A series of conduits and sewers from the site of the ancient Temple to the Brook Kedron, which admit an Arab walking erect, were discovered by him. Clay pipes have been found in the mines of the ancient city, of great thickness, which are supposed to have been connected with the pools of Hezekiah.

In remains of Roman works in use near *Zurich*, pipes of earthenware are laid, of short lengths and small diameter, delivering water under 200 feet head. The joints are made with large cubical blocks of concrete, in which the pipes are bedded and supported.

At *Nineveh*, drain pipes were found by Mr. Layard, leading from separate rooms of the dwellings, towards what was presumed to be a general system of sewers; this was also the case in Roman mansions; for which Vitruvius gives special directions.

The aqueducts and other public works of Chili, Mexico, Peru, and other parts of South America, many of which remain and are partially in use, give evidence of high rank in sanitary works, among the original occupants of this country. Baths and fountains were common in the houses of Yucatan in 1518. At *Tezcuco*, pipes were used as aqueducts from the mountains, and each house was thus supplied. "Moulded pipes, hard as stone," were used at *Churubusco* in the time of Cortez. The houses of the Incas of Peru, are said to have been provided with bathing cisterns of gold, with drain pipes of the same metal; and silver pipes are also described as in use for domestic pur-

poses. In all cases, and in connexion with the elaborate construction of water-works, baths, and fountains, which abound in the examples of ancient history, the use of equally perfect means of drainage must be assumed, if not particularly mentioned, and devices sometimes considered modern, are proved to be old; at *Herculaneum* the modern water closet has been exhumed, and the ingenuity of ancient devices in water machines for use and ornament is one of our lost arts. The descriptions of Cresy, Ewbank, and other collaborateurs, border on the fabulous, in hydraulic engineering.

The general and prominent lesson of this examination in things past, points out the great importance of sanitary works, as subjects of governmental care and oversight, and the need of more definite and systematic engineering study. The province of the engineer in this direction is much more important than that of the physician. If the one is a corrective, the other should be a preventive, and both bear no ordinary share of the responsibility of human happiness and longevity.

The particular lesson conveyed in the examples presented, as to details of method, shows a disuse of cesspools and the importance of tubular sewers, as collaterals to trunk sewers. The Roman practice, in this respect, abounds in precepts and warnings. Their branch sewer lines were small, very carefully jointed and lined, self-cleansing, and impermeable; these remain in use to the present time, while their immense, disproportioned structures are choked with deposit and valueless for present drainage.

We see that their sewerage was made direct from their houses and theatres to the sewers without the use of cesspools, and that their intermediate sewers were narrow, and high, and carefully built in dressed masonry with cement lining. In some cases, rubble stone-work was lined with brick-work, with inner cement plastering, which offered slight obstruction to flow and became very hard. Their engineers knew how to make cement mortar and believed in concrete; the same knowledge and faith, would be of service in this generation; and their authorities trusted to the skill of the engineers, but public rulers and boards are wise in their own conceit, now-a-days, overmuch.

Modern Practice.—Among modern cities, *Paris* presents the most perfect administration of the cesspool system. Since 1819, these have been made impermeable, and either stationary in brick-work and masonry, or movable, in structures of wood. Their contents, from the regulations for use and cleaning, do not find their way into the main sewers, but are carted to the *voirie*, except in the case of some public buildings, and in some modification of practice, to be adopted with the re-arrangement of the sewer outlets for general interception. The office of the sewers is therefore to receive the rain-fall, part of the street dirt, and the kitchen and waste water of the houses, which enters the street gutters and flows thence into the sewer gullies. The change of plan, will be made by the adoption of the tubular system, within or parallel with the main sewers; and large intercepting sewers are to be used for the protection of the Seine.

The sewers of the modern system, are of nearly oval form for four sizes from 4·16 by 6·25 feet, to 7·58 by 9 feet; there are five sizes above these, varying from 7·83 by 9·5 feet, to 16 41 by 13·41 feet high, which have water ways in the lower part, between double ledges, generally of 3·91 feet opening by 18 to 31 inches deep, with curved bottoms. The ledges are fitted with rails for the movement of cars, for sewer cleaning and other uses. Water pipes are laid in the upper part of the section, gas pipes being excluded on account of joint leakage. They are built chiefly of stone masonry, lined with cement plaster and whitewashed. Every morning and afternoon they are flushed 2½ hours from the hydrants. The cost, as given by Mr. Chesbrough, ranges from $6·56 to $ 31·50 per foot.

Up to January 1, 1806, Paris had constructed, under the old monarchy, 23,300 metres of sewers; Napoleon built 4804 metres, and the present extent is 226,600 metres or about 141 miles.

The cholera of 1832 dictated the new system of construction and arrangement, and the entire character of underground Paris has been changed since then, or from 40,300 metres to 5½ times the extent. Much was also done under Bruneseau, to correct defects in grade, section, and line, which seriously interfered with the proper action of the old drains, some of which date back to 1412.

In the oval form of the smaller sizes, but more particularly in the *cuvette* or water way, at the lower part of the main sewers, and the daily use of street hydrants for flushing, the French engineers demonstrate the necessity, for ordinary water flow, of concentration in narrow channels, for sewage. The inclinations of the smaller class vary from 1 in 1000 to 1 in 400; for the larger class, from 1 in 2000, to 1 in 1000. The proper concentration of scouring water is not, however, fully realized, and much of the sewage matter is removed by hand.

The city of *Amsterdam* has the cesspool system, the liquid sewage of the houses and streets being drained into the canals. Great care is taken in separating and removing the ashes, the street garbage and sweepings, and the house sweepings, but the canals are offensive depositories of filth and the health of the city is affected.

Berlin has but a short length of sewers, the street gutters being the common receptacle of that part of house sewage which does not enter the cesspools. The street gutters are flushed with water, and differences of opinion exist as to the purity of the atmosphere.

Hamburgh, since 1842, has abandoned the use of canals as drains and adopted main sewers of brick-work, and the general use of water closets in the houses, in connexion with an improved supply of water by pumping engines. A portion of the city is drained by the use of dykes and a scoup-wheel engine, for residence and agricultural use.

Worthing and *Leicester*, in England, of 5000 and 65,000 inhabitants, respectively, are illustrations of sewage delivery by pumping: at Worthing the same engine lifts the water supply 80 feet and the sewage 25 feet. It has a main brick sewer, with tubular feeders, 15 to 6 inches diameter. Water closets are to supersede cesspools. At

Leicester the sewage is pumped about 18 feet for ordinary flow. Brick sewers of circular form are used, varying from 12 to 54 inches diameter; depth 12 feet. The sewage is deodorized and made into manure; in 1857, on a weekly lift of 22,000,000 gallons of sewage and lime water, the loss in manufacture was 29 per cent. between cost and income.

Manchester, *Rugby*, *Croydon*, and *Edinburgh*, are illustrations of the use of pipe sewers.

Liverpool, *London*, *Glasgow*, *Carlisle*, and other cities have the combined system of pipes and large mains.

In our own country, *Chicago* and *Brooklyn* illustrate the general use of pipes, while *New York*, *Boston*, *Philadelphia* and other cities maintain large masonry sewers; and in many of our prominent cities the gradual abolition of cesspools may be considered a rule.

In many cases, permeable drains have been constructed. This practice, as in vogue at *Albany*, we have had occasion recently to describe in a report to the Common Council, from which the following extract is made:

"It was customary at Albany, sixteen years ago, when I was connected with the city department, to build square drains (18 inches in the clear), on plank bottoms, with side walls of brick or stone laid dry, and with flag stone coverings. Being penetrable, they readily wasted the water needed to scour out their solid contents, and were appropriated as runways for rats; for short districts, when made 18 inches square, they failed to operate as sewers, but became elongated cesspools, while for long distances, their want of strength exposed them to constant damage from storm-flow. In a sanitary point of view, they were therefore exceedingly objectionable, and have proved the causes of great mortality, since the immediate and complete removal of house sewage, is the only condition of public immunity and correct sewerage. In a business point of view, the damages to property by rats, and especially the damages by the contingencies of storm-flow to the sewers, to adjoining cellars, to street pavements, and otherwise, and the annual cost of cleaning and repairs, must have aggregated a heavy balance sheet against them. This system, I understand, is still partially continued, but it must be from want of attention to facts, apparent many years ago, and to the better practice of other localities."

Jersey City, which is comparatively low, with the Hudson in front and a salt marsh behind it, is also constructing some of its main sewers permeable. In the Report of July 1, 1862, the engineer, Mr. *Bacot*, makes the following statement:—

"The beneficial results already experienced from the building of three main sewers with their laterals in the Fourth Ward, as seen in the increased healthfulness of that section, and in the removal of the annoyances of flooded cellars and basements, amply compensate residents and owners of property assessed for their construction.

"In the construction of the main sewers, five courses of brick-work in the bottom arch of the sewer are laid dry, or without cement, allowing a constant drainage of the subsoil, the effect of which, in drying up the street and surrounding property, is manifest for a considerable distance on either side of the sewer."

There may be local circumstances which justify permeable sewers, by subsoil saturation from springs or other sources, independent of local rainfall. Here the benefits are limited in depth to the flow line of the drains, and wherever the external head does not exceed this,

the action of the sewer is, to a certain extent, vitiated. Water should not be lost from a sewer laterally. Flushing by tidal action is relied upon in this city for the main sewers. The laterals are pipes.

Of 116½ miles of sewers built in *New York*, from 1849 to 1863, the smallest size is an ellipse, 48 inches by 32. Under the head of repairing and cleaning, the expenditure for 1860, was $45,921, on 107 miles. The minimum size provides for the entrance of laborers. During the present year, oval pipes 29 by 19 inches, of hydraulic cement, have been introduced to a limited extent, and an effort is being made by Chief Engineer *Craven* to improve the general plan of city sewerage.

London, which ranks all other cities in population, has also the greatest extent of sewerage. Up to June, 1855, the metropolitan area contained 658 miles of brick sewers, which had been explored, with 150 miles approximately, unexplored, and 126 miles of pipe sewers, or a total of 934 miles, covered, with an approximate length, in open sewers, of 400 miles, or 1334 miles in all; nearly ten times the length in Paris, and about thirteen times the length in New York.

The area covered by the eight western, five northern, eight central, and six eastern districts on the north side of the Thames, and the twelve districts on the south side, is about 118 square miles. This includes the valley of the Thames from Brentford to Richmond, with the lateral valleys of three streams on the south side. In 1855 the Metropolitan District was organized under the "Metropolitan Board of Works."

Some of these sewers are supposed to be of Roman origin. A large number are uncovered, and those which have been built in, more particularly since 1756, being made to suit the special localties and emergencies, without regard to a general system, present a most singular combination of lines, sections, and grades, and a curious illustration of the transition state in city sewerage, to which Victor Hugo's description of the entrails of Paris, applies with great force.

Sewers in some cases commencing with a section 5 feet by 2·5, contract to 3·25 feet by 2, expand to 5·5 feet by 3, and with other changes, among which are reversed grades, have an outlet section of 3·25 feet by 2·25. Others are built of enormous proportions, which prevent concentration of ordinary water flow on their solid contents and form deposits which produce reactions in time of storm-flow. Their lines of feeders being arteries instead of veins, subject them to a water impact often fatal to their strength, at points where deposits reduce their water-way. The size of "*small sewers*," established by ordinance of the Westminster Board, Dec. 17, 1824, was a section 5 feet high by 2·5 wide, with arched top and bottom and straight sides, to have "a current of not less than one-eighth of an inch to each foot in length," or 1 in 96.

The Finsbury sewer at the outlet is 6·5 feet by 4·5; the Irongate sewer averages 8 feet by 3·66; the London Bridge sewer has an outlet of 8·25 feet by 6·75; the London Wall Sewer, 10 feet by 8; and the Fleet Sewer, 18·5 feet by 12; these are some of the enormous

mouths of the London cloaca, convenient channels of pestilent internal air currents.

The intercepting sewers recommended by the Commission of 1857 were to have a channel on the north side of 39 feet broad by 16·5 feet deep, and on the south side 37 feet by 16, with a grade of 6 inches per mile, with an outfall on the Thames, about 23 miles from the point of interception. These were calculated for a flow of 2·5 feet per second. The estimate of cost was £5,654,755. The total movement of sewage and rainfall from the metropolis was taken at 185,649,993 cubic feet per day, or 1,160,312,456 gallons, being about twice the flow of the Thames, which runs from 500,000,000 to 600,000,000 gallons.

In contrast with this system of arteries, the veins or pipes introduced in 1848 have been working their way against adverse currents, and with many curious results. In place of court and alley drains, 3 feet by 2·16, or generally 4 feet by 2·33, 6 inch pipes have been used to drain 150 houses; 12 inch pipes, placed within sewers 5·5 feet by 3·5, have more successfully drained their district of 44 acres; and 15 inch pipes have relieved sewers 5 feet by 3, otherwise accumulating deposit from 1200 houses, at 6000 cubic yards per month. It has been shown that these veins could be supplied to certain districts for the capital which represented the annual cost of flushing the original drains.

In its recent adoption of a system over 2000 years old, which theory advises and practice demonstrates; in its illustration of cumbrous and expensive devices; in its fearful chapters of mortality; in its long continued compilation of tests, analyses, plans, arguments, and commissions; in its admirable custom of publication, its extravagant outlay, and in various other respects, the history of London Sewerage is one of the most interesting and instructive lessons which can claim the attention of the engineer.

The sewerage plan of *Brooklyn* was arranged by its engineer (J. W. Adams, C. E.) in 1858, under very favorable circumstances; as the common use of cesspools and the delay in the introduction of water, had not required much previous construction of sewers to interfere with a correct plan.

With trunk mains, adjusted to its several water slopes, the city was districted for a general use of intermediate pipe drains. The relative proportion in length of sewers, under this plan, so far as built or actually under contract since 1858, will appear from the following schedule:

Trunk Mains.

72	inches diameter,	2,472	feet.
60	" "	6,699	"
54	" "	1,425	"
48	" "	15,405	"
42	" "	662	"
36	" "	21,282	"
	Total,	47,345	"

Tubular System.

24 inches diameter,	.	.	34,123 feet.
18 " "	.	.	59,102 "
15 " "	.	.	112,049 "
12 " "	.	.	310,104 "
Total,	.	.	515,378 "
Grand Total,	.	.	562,723 "

The appurtenances number 2116 street basins and 5403 manholes.

Contrary to the usual practice of large cities, not more than eight and-a-half per cent. of the Brooklyn sewerage in length is classified under the head of trunk sewers, or those which can be entered and cleaned by laborers, the system being considered self-cleansing; three-fifths are 12 inches in diameter, one-fifth 15 inches, and one-tenth 18 inches. Their operation has fulfilled the most sanguine expectations.

The Board of Works in Chicago, several years ago, sent their Chief Engineer, E. S. Chesbrough, Esq., to Europe, to examine foreign practice as a guide for his general plan of sewerage. On his return and by his advice, the tubular system was adopted and put under construction, under conditions calculated to test its efficiency severely. But all his subsequent reports confirm the correctness of his advice and sustain European experience in this respect.

We see, then, in contrasting ancient and modern practice, that the former was systematic and that the latter is chaotic. The ancients discarded the malignant and abominable cesspool system which with us is universal in custom; they not only drained public and private buildings, with great care to obtain "adequate and prompt disposal" of sewage, but in many cases, each room in a house was separately drained.

Their use of pipes of various manufacture, and in many cases of superior quality to present examples, shows a full appreciation of the benefits of this system, though their lavish use of flushing streams seems to have controlled the plans of main sewers. In respect therefore to ordinary sewage flow, as self-operative, modern practice has developed, at a late day, and to a limited extent, some improvement; but this improvement is yet in its transition state, while the entire history of modern practice, shows a want of educated supervision and a general defect in operation, which places it far below the "things that were," both in Europe and America, and by no means to the credit of our standard of civilization.

(To be Continued.)

The Ventilation of the New Theatres of Paris. By General Morin.

From the Lond. Civ. Eng. and Arch. Jour., Sept., 1863.

When I offered to the Academy, in the sitting of August 26, 1861, the Report of the Commission charged with the examination of the projects presented for the warming and ventilation of the new theatres

then in course of construction on the Place du Châtelet, I had the honor to inform it that I would hereafter communicate the results that might be obtained by the various systems that we might adopt. Although in execution the parties concerned have, in certain cases, notably departed from the principles of the science and from the results to which direct experiments had led us, the results obtained, when the machinery works regularly, are sufficiently favorable to show that we were in the right road to obtain a true solution of the problem; and that, if the indications we had given had been rigidly followed, the public would not have been exposed to certain grave inconveniences.

Before recording the results obtained, I will recall the principal bases of the programme, and of the objects approved by the Commission of which I had the honor to be reporter, and which comprised—M. Dumas, president, and Chaix d'Estange, senators; Pelouzé, Rayer Caristie, Gilbert, and Bastard, membres de l'Institut; and Grassi, physician. These bases consisted of the method of introducing the air—1. As Darcet had purposed, under the boxes of the different tiers and of the pit, by means of a double inclosure around each tier; 2. By the proscenium, and by the openings provided in the wall that separated the stage from the audience; 3. By the auxiliary openings destined for the summer ventilation, that were provided under the floors of the corridors of each tier of boxes, and which should derive their supply of air from the outside.

As to the discharge of the vitiated air of the audience part of the house, it was to be effected by certain openings placed at the level and at the bottom of the boxes and galleries, or in the upright sides of the steps of the amphitheatres. The warmth of the smoke flues during winter, that of the means of lighting in every season, and of the auxiliary gas-burners during the summer, it was calculated, would produce a sufficiently powerful draft. The volume of air extracted from the theatre was not to be less than 39 yards cube per spectator, supposing all the seats were occupied.

The project drawn up on these bases for the theatre of Le Cirque was rejected, notwithstanding the approval of it by the Conseil Municipale; and that which was presented for the Théâtre Lyrique was alone that adopted in its entirety. Without entering into details, which would be out of place here, it may suffice to say that for the Théâtre Lyrique, amongst the provisions for introducing fresh air prescribed by the Commission, one was found to be inconvenient, especially for the musicians, and another was omitted, in spite of our observations, by the architect of the theatre.

The first, to which we have been led with regret, consisted in admitting a part of the new air by a long and narrow passage, parallel to the foot-light, on the side of the actors. It was to be feared, and in fact it happened, that the fresh air, arriving cold, would be found inconvenient to the artists placed near its point of introduction. It became necessary to abandon this mode of introducing the air shortly after the opening of the theatre, which has confirmed me in the opinion

that air should only be brought into a room at some distance from the point of consumption. But, in addition to this suppression, found to be necessary, there has been another made, which in our opinion was disastrous, and no wise called for. It consists in suppression of the external openings intended to introduce the air directly, during the summer months, to the space between the boxes, instead of allowing it to follow uselessly the conduits leading from the basement of the building. It is to be feared, in fact, that in warm weather the supply of air would not be sufficient to prevent the elevation of the internal temperature. After having endeavored on several occasions to procure the adoption of this disposition, of which subsequent experience has proved the efficacy in the Théâtre du Cirque, where it was only introduced at a later period, we must decline the responsibility of the ventilation of the Théâtre Lyrique.

If the means of the introduction of fresh air that we had proposed had been diminished, firstly, during the construction, and afterwards by the manager of the theatre, the energy of the power for extracting the vitiated air had, on the contrary, been considerably increased, by the adoption of a mode of lighting which consists, as is well known, in the burning of 1160 gaslights above a gas platform, capable of consuming 8834 cubic feet per hour, which have been successfully reduced to about 4489 cubic feet. The considerable heat produced by the combustion of this quantity of gas in the cupola, and at the base of the upcast shaft, has caused an increase of temperature that increases the power of discharge.

Not to trespass upon the attention of the Academy, I will content myself with relating the results of the experiments carried on by my orders to determine the volumes of air introduced and of the vitiated air removed, during the performances, as also the observations on the external temperature.

Result of Observations made in the Theatre Lyrique.

Dates.	Volumes of air introduced per hour.	Volumes of air extracted per hour.	Volume of air extracted per hour and per person.	Temperature. Exterior.	Temperature. Interior.
	Metres.	Metres.	Metres.	Fahr.	Fahr.
Sept. 24, 1862,	19,685	67,748	40·80	62°	72°
Dec. 9, 1862,	30,850	60,051	36·28	48	69 to 72
Or about 50 yards cube . .			38.54		

Note.—It is necessary to state that the small volume of air introduced on the 24th of September, by the indraft chimney, was owing to the luxurious vegetation of the ivy, which had been placed for the purpose of hiding it, in the square of St. Jacques. As soon as the ivy was removed, the quantity of air admitted exceeded 26,000 metres cube per hour, as has been shown. The volume of vitiated air removed per hour and per place exceeds by the quantity of 28 per cent. that of the quantity provided. As to the temperatures observed, they indicated that on the 9th of December, from the hour of 8·30 to

11·30, the interior temperature did not vary much in the various parts of the house, and that it was on the average 73°.

Other observations, continued during twenty-one days, from the 18th of November to the 21st of December, 1862, have given as the mean temperatures of the different parts of the house, the following results:—

Upon the stage,	66 degrees Fahr.
At the orchestra stalls,	71 " "
At the different levels of the boxes,	73 " "
At the gallery, fourth story,	74 " "

During this period, the coldest day was the 16th of December, when the temperature did not exceed 31° Fahr., when in spite of the external cold it was found that the temperature in the interior was—

Upon the stage,	65 to 66 degrees Fahr.
At the orchestra,	71 " "
At the gallery,	73 " "

The warmest day was the 7th of December, when the external temperature was 56° Fahr.; the interior temperatures were—

Upon the stage,	65 degrees Fahr.
At the orchestra,	74 " "
At the boxes,	73 " "
At the gallery,	74 to 76 " "

Dispositions similar to those adopted at the Théâtre Lyrique have been adopted at the Théâtre de la Gaieté. The authorities have also, in this case, omitted the orifices for admitting air during the warm weather at the different stories; but they have been replaced by openings around the frame of the curtain, and these openings are especially reserved for the season. Some experiments, executed on the 13th of January last, have shown that, in spite of the small dimensions given to the conduits, and especially to the orifices of entry of the new air, the volume of this air can amount to 16 yards cubic, or even to 20 yards; and that the volume of foul air discharged amounted to 38 or 40, yards; the observation of the temperature, made on the same day, was—

On the exterior,	44·6 degrees Fahr.
At the pit,	72 " "
At the orchestra,	71 " "
At the first tier of boxes,	72 " "
At the gallery,	77 " "

But it is necessary to remark that the consumption of gas, which, at the rate of 1680 burners, ought to be about 7120 cubic feet per hour had been reduced, from motives of economy, to 2200, or thereabouts, which diminished the activity of the draft, and increased, consequently, the heat. As a proof of the great influence of this restriction of the lighting, it was found that with the full power and combustion of the gas, the volume of air evacuated was 122,200 cubic yards per hour. It is moreover, very seldom that all the places are occupied; and as it is possible, when that is the case, to push the lighting to a more active degree, the section of the passages, although too small for this theatre, would allow of the introduction of a sufficient volume of air to

prevent the temperature from ever rising above 72° or 74° Fahr. at the boxes, or 75° to 77° Fahr. at the gallery. We lately had occasion to prove this; for, on the 25th of February, their Majesties assisted at a representation at this theatre. There were in the house 1434 spectators, and during the whole evening the temperature at the first floor of boxes remained within the limits of 72° to 74° Fahr.

As to the the Théâtre du Cirque, although the dispositions adopted for the introduction of air, and even for the discharge of it, was much less complete than those the Commission had indicated, we were able to identify that, on the 11th August, 1862, the volume of air discharged was 107,000 metres cubic; which give for the 2976 places that exist in this house about 36 cubic metres per place and per hour. But the volume of air introduced by the regular orifices, disposed for that purpose, was reduced by the incomplete arrangements to a third of that quantity. It is necessary also to add that, since the above observations were made, the service of the different parts of the machinery has been treated with such negligence that the results have been very far from being the same. From experiments made on the 16th of January, 1863, it would appear that the vitiated air removed was only about 53,000 metres cubic, or about 17·80 metres cubic per place and per hour, instead of being 30 metres cubic, the minimum fixed by the Commission.

An important fact was observed in this theatre, that may have an influence upon the state of the art; it was with respect to the orifices for the admission of air directly from the outside which we had prescribed for the summer ventilation. The engineer employed to construct the apparatus having had recourse, for the two lower stories, to the indications of the Commission, found that he obtained by that means nearly 13,000 metres cubic of air per hour to those two stories, although the size of his passages was only about 3 inches, instead of their being 6 inches, which he might have made them in the beginning. If this disposition had been adopted, as we had demanded, in the beginning for all the stories, it is evident that the parties charged with the ventilation would have been able thus to have disposed of a quantity of fresh air equal to about 50,000 metres cubic per hour. It is to be hoped that this experimental demonstration of the correctness of the principles that had guided us upon the admission of air in the warm season will not be lost on a future occasion when other works have to be performed.

It is necessary to add, that the Commission has indicated, for the building of the theatre of Le Cirque the construction of a special chimney, which according to the project that it approved of ought to have been placed over the stage, for the case of the representation of combats in which much powder was consumed. This chimney was only to be opened at the precise moment when it would have been wanted, and it would have been provided with gas-burners to increase the draft of the smoke, and to prevent its spreading among the audience. This precaution was neglected, and experience soon showed

the necessity of it. During the representations of the new piece of the "Battle of Marengo," the gunpowder smoke, drawn by the general current of air (which by the dispositions adopted, set from the stage to the bottom of the theatre), came out at the level of all the stage boxes, and inconvenienced the spectators very much. The temperature rose in the upper tiers of boxes to about 84° and 86° Fahr., instead of being 72° to 75° Fahr.

When apparatus, well constructed and in a good state, have for a certain time given such results as we have shown with ease, it must be sufficient to obtain similar results for a continuance to exercise an active superintendence and a certain amount of good will. Consequently if in certain theatres it is sometimes too hot, and sometimes too cold, it is important that the public should know that it is not the apparatus adopted nor the dispositions of the establishment that are in fault, but the mistaken notions of economy on the part of the parties intrusted with their management. The administration of the city of Paris will, we have no doubt, cause measures to be adopted to insure the public the advantages it has obtained at such a cost, and will enforce the precautions that will insure the improvement so long sought for in the theatres.

In fine, the experiments conducted at the Théâtre Lyrique and at the Gaieté where the principles laid down by the Commission of the new Theatres of Paris were followed—although in a manner too confined and incomplete—have proved that a thorough ventilation, imperfect perhaps in uniformity, may be obtained; and above all, that a satisfactory moderation of temperature was obtained in every part of the houses. There is therefore every reason to believe that, if profiting by the trials of the system which the city of Paris has had the boldness to adopt upon the indications of science, those principles should be still further applied, the public would be able to enjoy the intellectual pleasures of the theatre, without too great a sacrifice of its health; thus the arts would gain by the ameliorations proposed for the public health. And, in order that the public may appreciate the value of the progress already realized and to be realized, it may not be out of place to observe, in conclusion, that from observations made by an independent authority, it was found that, in July, 1859, there were often observed in the Opera, at ten o'clock in the evening, the temperatures of 86° to 89° Fahr. at the level of the first row of boxes, and 100° and 104° Fahr. at the higher levels. From some other observations that I have made this winter, I find that at the first floor of boxes the temperature is from 71° to 74° Fahr., and in the higher places, from 84° to 86° Fahr., notwithstanding the communication of the boxes with the passages, whose temperature is only on the average 68° Fahr.

Such having been the state of things when we were called upon to occupy ourselves with the question of ventilation, it is easy to see the progress that we have been able to make with it, and to encourage the hope of our being able to resolve the questions connected with it in future construction.

On the Construction of Wrought Iron Lattice Girders.

By Thomas Cargill, C. E.

(Continued from page 309.)

From the Lond. Civ. Eng. and Arch. Journal, Oct., 1862.

The security of any structure of iron, or other substance consisting of separate portions of the same or different materials united together, each individual portion being sufficiently strong for the purpose intended, depends unquestionably upon the efficiency or inefficiency of the manner in which these component parts are severally connected together. This is in no instance more apparent than in wrought iron girders of every description. They present, in a greater or less degree, a complete mass of combinations, being composed of separate portions of iron, whose dimensions, even in a bridge of so small a span as 60 feet, bear but a very small proportion to the total length of the girder. An increase of span further augments the relative disproportion, while it also increases the number of the component parts. This latter alternative would not necessarily take place were it possible to increase the dimensions of the component parts in the same ratio as the span was lengthened. Unfortunately, the great difficulty experienced in rolling plates beyond a certain length, so as to preserve the metal perfectly homogeneous, and consequently the strength uniform throughout the whole plate, precludes us from employing plates, or in fact any other description of rolled iron exceeding very limited dimensions. The length of the plates usually employed in wrought iron girders does not exceed 12 feet, although there is no doubt that plates rolled 18 or 20 feet long might be depended upon with perfect safety. There is another reason also, and a much weightier one, which limits the introduction of long and heavy plates in a girder, viz: the item of cost, which increases in a more rapid proportion than the mere dimensions of the iron to be rolled; the breadth of the bar or plate very considerably affects its cost. At the time of the construction of the Britannia and Conway Tubular Bridges it was very difficult to obtain plates 12 feet long, rolled with an homogeneous distribution of fibre.*

Next to a solid balk of wood, a cast iron girder in one casting offers the simplest method of spanning any distance, for with the exception of a few bolt-holes for the purpose of fastening it to the bed-plates and attaching the superstructure, the material remains intact, and the expense of workmanship and skilled labor is thus reduced to a minimum. The very small range of span to which cast iron is applicable, and other considerations, chiefly want of confidence in the material, have very justly restricted its use. The preference is doubtless very frequently given to wrought iron in instances where the former material might be employed with perfect safety and far more economy.

Before proceeding further with this part of our subject, and confining our attention to the particular class of girders of which we are treating, a distinction must be made between mere joinings or connexions of different pieces of material and a joint. The simple at-

* Vide Mr. Fairbairn's work, "Account of the Construction of the Britannia and Conway Tubular Bridges, with an account of the elaborate experiments to determine the best form of construction."

taching of one piece of iron to another, such as for example the attachment of a bar of the web of a lattice girder to the flanches, does not constitute, properly speaking, a joint, which will presently be defined. The two descriptions of joints most generally known, are the lap and the butt joints. The former of these should never be employed in girder work, and except in small and unimportant specimens of iron work might be disused altogether, as there is no situation, not even in boiler work, where it is usually employed, that a butt joint might not be advantageously substituted in its stead. This supposition premises that the action of the heat would equally affect all parts of the joint, both plates and wrappers.

In treating in future of joints, it will be understood that by the term is meant a junction of two portions of iron which abut against one another end to end, and are covered for a certain length on each side of the junction by one at least, or what is better, by two pieces of iron called covering plates or wrappers, which are riveted to one another through the abutting portions of iron. An example of such a joint is represented in Fig. 1, and requires but little explanation to render it intelligible. A B are the two portions of iron to be join-

Fig. 1.

Scale 1-24.

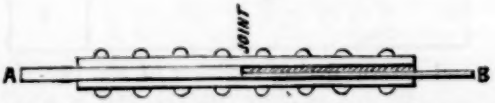
ed, and C C, D D, are the covering plates, one above and the other below the joint. Pieces of iron put together as shown in the figure will be said to be jointed together; in other positions they will be considered simply as joined to one another. In some exceptional cases one of the covering plates may be dispensed with, if very rigid economy of material is desirable. The nature and direction of the strain will be the best guide for determining when this may be done, but, even under the most favorable circumstances, a joint is but badly protected by having a covering plate on only one of its surfaces. As it is only in certain portions of a girder that this plan could be adopted, the saving of metal would be very slight in girders of even large span, and the attendant risk would more than counterbalance the economical advantages.

In a lap or boiler joint, the "lap," that is, the distance which one plate overlaps the other, answers the purpose of the wrappers in the butt joints, but not so effectually. There is this difference to be noticed in a lap and butt joint; in the former, the next section of the plates is never less than that of the thinner of the two plates which are jointed together; in the latter the next section of the plates at the joint (see Fig. 1), is absolutely nil, and must be entirely replaced and compensated for by that of the covering pieces. The simplest form of a butt joint is shown in Fig. 3, which represents a plan of two pieces of bar or plate iron jointed together by a single row of rivets, with an upper and lower covering piece; one covering piece only is

shown in the figure, but an exactly similar one is supposed to be on the reverse side; an elevation of the joint would show the other wrapper; but for the elevation of the joint shown in Fig. 3, as well as of many others of which the plans will be given, reference must be made to Fig. 1, which will serve to explain them, as valuable space cannot be taken up by needless repetition of figures nearly identical with one another.

If we make S and S_1 the net sections respectively of the two plates or other portions of iron to be jointed together, and put A for the area of the total number of rivets which will be required to hold the joint, we shall have the following equation, provided that the same constant be employed for both the iron and the rivets: $A = S + S_1$. Making $S = S_1$ we have $A = 2S$. Where possible S should always equal S_1, or what amounts to the same, supposing the breadth of the plates to be equal as is generally the case, if t and t_1 be the thickness of the

Fig. 2.

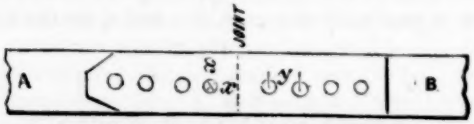


plates, t should $= t$. Should it be otherwise, and supposing the difference of the two sections to arise from a difference in the value of t and t_1, and consequently $\frac{S}{S_1} = \frac{t}{t_1}$, it becomes necessary to insert a packing piece over the thinner of the two plates, as shown in Fig. 2, where A is the thicker plate, B the thinner, and the packing piece is represented by the shaded lines, as if in section. Calling C the length of the covering plate, and P the net total section of the packing piece, we obtain $P = (S - S_1) \times \frac{C}{2}$. There are, however, other and weightier reasons affecting the riveting of the joint, which render it unadvisable to joint two plates which are of very different thicknesses or of very dissimilar sections. In deducing the strength and different dimensions of the parts of a joint, it will be sufficient to limit ourselves to a consideration of one-half of the joint, as the same number of rivets will be required for the other half, and the covering plates will be also similar on each side of the joint whenever the two plates have the same section. When the sections are different the value of S must be taken equal to the net section of the larger plate, as the joint would not have an uniform appearance with an unequal number of rivets disposed on each side. The covering plates also should be of the same section as the larger plate, and would require the same number of rivets. It follows from this that whenever two plates or bars of iron, having a very considerable difference in their sectional area, are jointed together, there must be either an excess of strength in the rivets on one side of the joint, or in the plate on the other. If $S - S_1$ be not very great, a mean section might be taken as the datum for designing

the joint, or putting s_2 for the mean section we find $s_2 = \frac{s + s_1}{2}$. In the following investigation, the joints will be supposed to be under a uniform tensile strain, but the conclusions arrived at respecting their strength and security will hold *à fortiori* for those under a compressive or any other kind of strain.

It is a disputed point whether the two ends of plates forming a butt joint, and under a compressive strain, can be considered fairly in contact with one another to such a degree as to afford any increment of strength to the joint. The absence of experiment and other reasons preclude us from calculating on any theoretical increase of strength on the above supposition. With good sound workmanship, double co-

Fig. 3.



vering pieces, and careful fitting together of the two abutting plates, the ends undoubtedly are in close contact, and a small increase of strength in joints subjected to the above strains may be practically fairly counted upon, although it cannot be introduced into the theoretic calculations. Even if the joints at first were imperfectly in contact, yet when the girder had been subjected to its proper load and had undergone its permanent set, they would be brought into close contact when all the various parts had settled down to their bearings. Let us take the example of the upper boom of a girder which is under a compressive strain. The strain tends to drive the two abutting ends of any two plates forcibly together. It is evident that the upper wrapper is therefore nearly altogether relieved from strain, and that one covering plate on the under surface of the joint would, strictly speaking, suffice to prevent the plates from slipping past one another. This is one instance in which, according to the judgment of the designer, one covering plate may or may not be dispensed with.

In designing joints, the following particulars require to be known: the number of rivets necessary to hold the joint, their distance from one another, and from the edge of the plates and joint, the dimension of the covering plates, and the general disposition of the different parts. The diameter of the rivets to be employed depends not so much on the amount of the strain as on the thickness of the bars or plates to be jointed. For every thickness of plate there is a certain diameter of rivet proportioned to it. This proportion has been decided by experiment, and tables have been given for the purpose. Let A equal the total area of the number of rivets required for half the joint, or for one side of it, and s the next section of plate, then $A = s$. Put $N =$ the number of rivets required on one side of the joint, s the net section of the larger plate, or of one of the plates if they are of the same size, and

a the area of a rivet: then for a general formula $N = \frac{S}{a}$. To refer to the simplest case, as shown in Fig. 3. Let A B be the two plates to be jointed. Put b for the breadth of the plates, d for the diameter of the rivets, n for the number in the same straight line across the breadth of the plates, and t for the thickness of either plate; then $S = (b - nd)t$. Substituting for a its value $= \frac{\pi d^2}{4}$, we find

$$N = 4t\left(\frac{b}{\pi d^2} - \frac{n}{\pi d}\right) = \frac{4(b - nd)t}{\pi d^2}.$$

In Fig. 3 $n = 1$ and $N = 4\frac{(b - d)t}{\pi d^2}$.

It is evident that so far as the plates are concerned, and the wrappers also, the best disposition of the rivets would be that which would cause the joint to have no decided tendency to fracture in any one direction rather than in any other. As, however, the breaking strain is never even approximated to under a severe test load, much less when the girder is merely undergoing its usual working load, it will be seen that this theoretical consideration cannot be adhered to for various reasons, nor is there any necessity for so doing. In so simple a case as Fig. 3, the distance of the centre of the rivets from the edges of the plate will equal $\frac{b}{2}$. A similar value from what has been stated above will apply to the distance from the centre of the first rivet to the joint. It is generally the rule in joints of this description to make the distance from the centre of the rivets also equal x, or $x = y$ (see Fig. 3). The more correct value of y would be $y = \frac{2x + d}{2} = \frac{b + d}{2}$. With the rivets disposed in this manner, that is along the centre line of the plate, and with the correct value for y, the section of metal outside the rivet holes will be a maximum in every direction, and were the plates composing the joint subjected to a uniform strain per square inch, until the breaking point was reached, there would be no tendency to fracture across any particular line, although there is little doubt that the plate would go right across the rivet holes in its centre. The distance also of the centre of the last rivets from the end of the covering piece will also equal x. On reference to the figure it will be seen that the distance between the first two rivets on each side of the joint is double that between the others. This does not influence the net section between the rivets so far as the plates are concerned, but it affects the covering plates, which are twice as strong at this particular point than elsewhere, and indicates that these two rivets should be shifted nearer to one another. It is evident also, that practically the first two rivets should be near the joint, whatever distance may be assigned for the others, in order to prevent any tendency in the two abutting ends of the plates to rise up or curl under a strain. If the bars or

plates to be united be less than 4 inches in breadth, the arrangement must remain as shown in Fig. 3, as the centre of a rivet should never be nearer to a joint or the edge of a plate than 2 inches, and this is leaving but a very small margin outside the rivet hole, supposing the rivet to be so much as $\frac{3}{4}$ of an inch in diameter. For the length of the wrappers for bars or plates of about this dimension or under, we shall have, using the notation employed above, and supposing $x=y$, and making $l=$the half length of the covering pieces, as we are considering only half the joint, we have $l=(n+1)\,x$, $x=\frac{b}{2}$ and $l=\frac{(n+1)b}{2}$.

If we make $x=$the distance from the centre of the first rivet to the joint, and from the centre of the last rivet to the end of the covering pieces, and $y=$the pitch of the remainder of the rivets, we find $l=2x+(n-1)\,y$. Substituting for x its value and for y its value, $=\frac{2x+d}{2}=\frac{b+d}{2}$, we obtain $l=b\,\frac{+(n-1)\,b+d}{2}$, and finally,

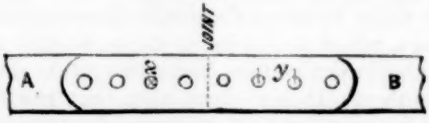
$$l=\frac{n\,(b+d)+(b-d)}{2}$$

Where the breadth of the plate exceeds 4 inches, and only one row of rivets is employed (see Fig. 4), we have for the value of l, putting p equal distance of the centre of the first rivet from the joint, and also of the centre of the last from the end of the covering piece, and y for the pitch as before, $l=2p+(n-1)\,\frac{b+d}{2}$, making $p=2$ inches, as the least value it should have, we obtain

$$l=\frac{4+n\,(b+d)-(b+d)}{2}.$$

It has been found in practice that the ends of the covering pieces, more particularly the corners, have a strong tendency to lift or rise up slightly above the plates, the amount of which depends principally upon the distance of the last rivets from their edges. To obviate this tendency, and also to economize material, the ends of the covering pieces are often beveled off, as shown in the left-hand half of the joint in Fig. 3. They might also be rounded off, as in Fig. 4, which distributes the section of the wrappers better round the rivet holes, although it is not so convenient in practice as the method in Fig. 3. In order to be convinced on this point, it is only necessary to watch a bridge when newly erected and after it has been some time in use.

Fig. 4.



If the joints are well designed and the workmanship good and care-

fully executed, it will be impossible to insert even the thin blade of a knife between the plates and the covering pieces; if the same attempt be made after the bridge has been for a short time under traffic, no such difficulties will be encountered. I have seen instances, where, in consequence of the last rivets being too far from the end of the wrappers, they have risen an eighth of an inch above the plates underneath them, and have, in consequence, caused a very injurious strain in a diagonal direction on the plates and wrappers.

To proceed to another example; let us take the case where the plates (for so we will call them), are sufficiently broad to take two rivets in the line of their breadth, or across the plates. Fig. 5 represents a plate of such a dimension, and two arrangements of the rivets in the joint are shown; one to the right of the figure, where there are two rivets in the same line across the breadth of the plate, and to the left where there is only one, or in other words where the pitch of the rivets is alternate or breaking joint. A brief allusion was made to this part of the subject before, but we will now consider both the theoretic and practical advantages of the one method over the other. The theoretical advantages will consist mainly in the difference of the two net sections. The net section on the right and left will equal $s=(b-nd)t$. On the right n will equal 2. On the other n will equal either one or two, according as we take the section along the line C D or C E. If the section be taken along the line C D, it is evident that the gain of metal will equal the diameter of one rivet. It will, however, be fairer for the comparison to take it along the line C E. It will be seen at once, on reference to the figure, that while there is a gain of metal along the line C E, as compared with C D, there is also a loss equal to the diameter of a rivet. So far as the two sections are concerned, therefore, an equality will exist when the gain of metal along the longer section equals the loss sustained by the rivet hole. Calling p the pitch of the rivets in both directions, and s, s_1 the sections on the line C D, C E, we have

$$s_1-s=(b-nd)t+\sqrt{\left\{\left(p^2+\frac{p^2}{4}\right)-p\right\}t}-(b-nd)t.$$

The increase of section is represented by the quantity

$$\sqrt{\left\{\left(p^2+\frac{p^2}{4}\right)-p\right\}t},$$

or neglecting t it equals $\sqrt{\frac{5p^2}{4}}-p=\sqrt{5}\times\frac{p}{2}-p$.

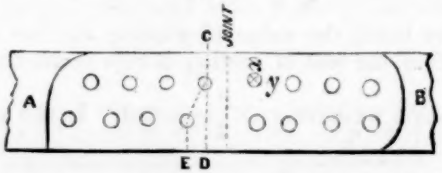
On the other hand, the value of n along the line C D $=1$, and on C E $=2$, therefore the loss of section is represented by d, and for an equality of section we have $\sqrt{5}\times\frac{p}{2}-p=d$. In the majority of cases it will be found that $\sqrt{5}\times\frac{p}{2}-p$ will $=$ or $>d$, and even when less than d it will, on account of the practical advantages arising from this

disposition of the rivets, be preferable to always employ an alternate pitch of the rivets. From what has been said respecting the curling up of the ends of the covering pieces it is manifest that the same reasoning applies to all the edges of either plates or wrappers, and consequently that the rivets along or nearest the edges must not exceed a certain distance from them. The thickness of the plates to be jointed will be the best guide respecting this point. Putting x for the distance of the centre of the rivet from the edge of the wrappers and plates which are presumed to be flush with one another, t as before, and r for the rise of the wrapper over the plate, r varies as $\frac{x}{t}$

In determining the number of rivets necessary for the joint it must be remembered that, where $\sqrt{5}+\frac{p}{2}-p=$ or $>d$ the value of n in the formula $s=(b-nd)t$ will equal 1. As a rule in girder work the value of p will lie between 3 and 4 inches when the rivets are in the same straight line across the plates, and between 6 and 8 inches when the pitch is alternate. In the former instance the half covering piece will equal $l=n\times p$, and in the latter will equal $p\frac{2n+1}{1}$. The size and magnitude of the iron work in the bridge must in some measure influence the value of p, for as l varies directly as p, a large amount of superfluous metal might be introduced in the wrappers were too large a value given to it. Whatever value may be assigned to x, in no instance should p ever $<\frac{2x+d}{2}$, so that the minimum value of l will be be $l=\frac{(2x+d)\times(2n+1)}{4}$.

Independently of the theoretical superiority of the latter over the former method of disposing the rivets in a joint, a much stronger and more efficient joint is obtained by causing the rivets to break joint. It was found by experiment that the increase of strength afforded by the alternate placing of the rivets was nearly one-half above that given by the other method.* There is a slight advantage, or rather there was some time ago, in placing the rivets as shown on the right hand side in Fig. 5. This arose from the greater facility for punching,

Fig. 5.



which it afforded, but now that our iron work establishments are con-

* This was the proportion arrived at by Mr. Fairbairn, in his experiments "On the strength of iron plates united by rivets, and the best mode of riveting."

ducted on so much larger a scale than formerly, and our appliances and machinery are so greatly improved, it is a matter of no importance in this point of view which method is employed. It is worth remarking that at the commencement of the Britannia Bridge the rivets in the joints were not inserted with an alternate pitch. It was discovered however afterwards that the reasoning was erroneous which had led to the adoption of such an arrangement, and in future it was abandoned in favor of the other method of inserting the rivets. Experiments also confirmed the fallacy of the first theory.*

The above examples of joints are the simplest which could occur, and admit of the most favorable theoretical distribution of the rivets and other parts. It is however but rare in actual girder work that opportunities so advantageous present themselves. The intervention of angle-irons, the attachment of the web to the booms, and other considerations, oblige us to alter the disposition of the rivets and joints very materially from what would be the most preferable method either theoretically or practically. The effect of the other contiguous parts of the girder on the rivets and joints will be seen in our next.

* Vide Edwin Clark's work "On the Britannia and Conway Tubular Bridges."

(To be Continued.)

MECHANICS, PHYSICS, AND CHEMISTRY.

New Researches upon the Preservation of Building Materials.

By F. KUHLMAN.

From the Lond. Civ. Eng. and Arch. Jour. Sept., 1863.

In my previous researches upon the hardening of stones and the preservation of building materials, I had endeavored to impregnate the porous stones, and the renderings in plaster or lime, with some mineral substance capable of combining with those bodies or those coatings. Amongst the chemical combinations that were unattackable, and susceptible of augmenting the hardness, the substance that seemed to me to merit the preference was the silicate of potash. But, because this agent is of general efficacy, it by no means follows that there may not be some circumstances in which its action is partly paralyzed by causes depending upon the nature of the materials, or of the conditions in which they may be placed at the moment of their application.

It is thus experience has shown that when the silicatization is applied to ancient constructions, its efficacy may be unsatisfactory, if there had previously existed in the walls a commencement of decay developed under the influence of ammoniacal exhalations and constant damp. In such cases, the exterior coats of the walls and of the renderings, although hardened by the silicatization, are thrown off, and finish by detaching themselves by the formation of nitrous salts, and the decay continues to make progress. The expedient that I have found to answer best in these cases, for brick walls in particular, consists in removing entirely the coating and the joints of the work beneath in

mortar, and after having warmed the place by means of a movable brazier, to cause them to absorb, by means of a brush, or by casting it upon the work to be protected, some pitch arising from the distillation of coal, and applied as warm as possible. After cooling, the parts of the wall covered by the pitch can be recoated with a new rendering of plaster, which will adhere perfectly well, and to which the silicatization will insure the best conditions of durability and unalterability. Gas-tar has become of very general use in the towns of the north of France, to protect the basements of the houses from the effects of the external damp; but they have not yet been able to prevent the damp from rising in the interior by the effect of the capillarity. In my factory of chemical products I make a still more general use of this tar. I apply it hot upon all the exterior walls of the ovens for decomposing salts, burning pyrites, concentrating sulphuric acid, &c.; and I impregnate, by immersion in boiling tar, the tiles destined to the covering of roofs, particularly those where there are any acid vapors produced.

In England, in the soda factories, where the hydrochloric acid is generally condensed in chimneys or towers containing coke kept constantly wetted by a stream of water, the flagging which serves as a base to these towers, when it is of a porous nature, is immersed in hot tar before it is laid down. In other circumstances, the tar is used to color tiles made of porous clay for general use.

If, in certain cases, the application of mineral waters to the preservation of walls would be difficult, it would not be impossible to employ organic matters less exposed to alterations than the resins and bitumens which the ancients had employed as the basis of the preparations for preserving the dead bodies, and which by their unalterability, represent, in a similar manner to coal, a period of cessation in the decay of organic substances. The efficiency of coatings of a greasy or resinous nature, even though superficial, against the destructive action of the sea air bringing with it sea-water, was proved to me in the course of last summer, when I had occasion to examine the rapid progress of decay that was taking place in the porous sandstone of the chapel of St. Eugenie, on the borders of the sea at Biarritz. The stones of this chapel, whose construction only dates from the year 1858, are profoundly corroded on all the points exposed to the wind; and I observed this peculiarity in the stones which, before being put in place, were marked with oil color, in black, that the parts covered with the color were protected against alteration, so that the numbers now stand out in relief with great distinctness. The example of these figures in relief, in which the preservation of the stone was assured by the merely superficial application of the greasy or resinous matters, made me think that in a number of cases the bitumens and resins might be made to play a very useful part in the preservation of buildings or sculptured decorations, if, instead of applying them to the surface, they were made to penetrate into the interior of the stones without decomposing their surface, as I had recommended should be done with the applications of mineral solution.

I have made numerous essays to assure myself of the possibility of

this penetration by employing pitch derived from the distillation of coal-tar; it is a matter easily met with in commerce, and whose price (4 or 5 francs the 100 kilogrammes) is not high, and which serves now-a-days only for the manufacture of the small bricks made from the waste coal. I caused to be boiled in it, without any other pressure than that of the atmosphere, stones, carved or roughed; bricks; objects made in clay, or simply dried in the open air which are able to form a pottery without being burnt or varnished. These are boiled in vessels of cast or wrought iron, and I thus obtain a penetration of the pitch to a great depth, and with that a considerable degree of hardness and a perfect impermeability. These properties would render such materials essentially fitted for the construction of the foundations of houses, for the coverings of walls, for hydraulic works, and particularly to those exposed to the sea air. I have also formed, with hot tar and some mineral substances in powder, pastes that are more or less fusible under the effects of heat, according as they may contain in their composition more or less tar, and which are susceptible of being moulded, with or without compression, into bricks, tiles, and into architectural ornaments of every kind. The matter whose incorporation has afforded the best results is the oxide of iron resulting from the combustion of the pyrites, and which, when mixed with a quarter of its weight of tar yields a paste which presents a hardness and a sonority that are very remarkable.

I have no necessity to dwell upon the frequent applications which such paste as are impermeable would admit of, in building, in hydraulic works, especially in those washed by the sea, in which experience has shown that all cements sooner or later, suffer disintegration. These materials, cemented together with melting tar or put together in the same manner that the constructions are formed of pounded clay (*en pise*), would make monoliths whose durability ought to be tried in our harbors.

The application of the siliceous dissolutions upon plaster was that which yielded the most unsatisfactory results, because at the moment of contact there was an exchange of acid, and the production of gelatinous silica, which formed on the surface of the plaster an impermeable coating, which, in its turn, prevented the penetration of the silica to the centre of the mass. This does not occur with the calcareous stones, nor even with alabaster, in which the isolation of the silica, or its combination with the calcareous base, can take place more slowly. The siliceous coating produced upon plaster casts by the silicate of potash, present moreover the disadvantage, when they are produced by strong dissolutions, of cracking, and detaching in scales. The application of bituminous substances to preserving plaster then attracted the whole of my attention; and I am happy to be able to say that the chemical composition of the plaster, instead of being an obstacle, as in the case of the silication, to the hardening and impermeabilty of the body, on the contrary, tended to realize those results.

Indeed, not only does the melting tar penetrate the plaster by the

aid of its great porosity, in the same manner in which it filters between the molecules of calcareous or friable sandstones, and thus destroys their peremeability, but it also replaces the water of hydration in proportion as the latter escapes, when the objects that are cast in plaster are plunged into a bath of melted tar, whose temperature may be 600° or 700° Fahr., although the water of hydration escapes at 230° or 248° Fahr. The effect of the expulsion of the water of hydration under the circumstances is easily understood; but that which it was hardly permitted to be hoped, and whose re-action is the most interesting in a scientific point of view is, that the objects thus cast in plaster should retain, without change of form, the outlines they had received in the moulds, and that the substitution of the tar for the water should be produced to great depths from the surface, when the ornaments, or the statues in plaster, remained a sufficiently long time in the bath of boiling tar. I obtained a very striking proof of this molecular substitution by the transformation of crystals of the natural sulphate of lime into a black shining mass having the same crystalline form, and in which the water of crystallization had been changed, and the tar substituted. This constituted a singular instance of pseudo-morphism.

I have shown, in a work upon Ethers, published in 1841, that alcohol and sulphuric ether could form, like water, combinations which were crystallizable with certain acids and anhydrous chlorides; but it is difficult to admit that the same thing should happen with plaster, for it is not only the tar, which without altering the crystalline form of the gypsum, can substitute itself for the water of cyrstallization, but also of several other fatty or resinous matters; stearic acid is of this number. When, instead of melting the stearic acid in a sand-bath, as it is the custom to do, figures in plaster are moulded and impregnated superficially with this fatty acid, and the bath of stearic acid is heated to 330° or 400° Fahr., it is easy to see that the water of hydration is expelled by a great bubbling that is produced by the passage of the water through the reacting liquid. It is a question then, in my opinion, of a simple infiltration, determined by the vacuum that the water of filtration leaves in proportion to the elimination thereof of an infiltration or intimate penetration which takes place under such circumstances that the crystalline body should not cease to retain its form, and should acquire a great degree of hardness, which would not be the case when the water of crystallization is driven off by heat alone. It must be the case that this penetration, although the result of an action purely physical, must be very intimate; for washings with ether and benzine, repeated frequently, succeed in detaching the tar from the transformed crystals, however well pulverized they may be.

My manner of explaining the phenomenon observed seems the more admissible, because the number of the substances that can thus substitute themselves for water is considerable; but care must be taken, as the chemical action of all the substances upon the plaster is not the same, and they cannot be substituted indifferently to the dehydrized plaster at a temperature sufficient to drive off the water of crystallization, in the same manner as tar, stearic acid, oil, &c. In order

to effect this substitution, it is necessary that the liquid in question should be able to moisten the plaster; for I have found it to be impossible to substitute sulphur, or mercury, for the water of crystallization.

I have already shown, in a work upon Epigénisis, that there were numerous instances known in which crystallized bodies preserved their form, although they had lost one or more of their constitutent principles: it is thus that I have converted the binoxide of manganese into the protoxide, and into an intermediate oxide; the oxide of copper, and the natural carbonate of lead, into copper and lead; the formiate of lead into the sulphate; all the while preserving to the new bodies the crystalline forms of the bodies which gave rise to them, with simple modifications in their porosity. It is in this way that I recently showed that crystals, of acedote can be transformed into hausmannite without changing their form. However this may be, the substition of tar for the water of hydration in moulded plaster, in gypseous alabaster, and in isolated crystals of the sulphate of lime, will fix the attention of geologists and crystallographers; and it is not impossible that a deeper study of this phenomenon may lead to some new observations that may throw some light upon the transformations to be met with in the history of the globe.

Under any circumstances, I hope that the interest the Academy may attach to these observations may be increased by the great resources that the facts I have recorded place at our disposal, for the increase of our houses in healthiness, and the improvement of their decoration. They will allow plaster moulded, and alabaster carved, to be used as sculptured ornaments, impervious to wet, and unattackable by the frost, and without any of the defects that now exclude plaster from the decoration of our houses and public buildings.

M. Payen cited, in confirmation of the observations of M. Kuhlman, some facts that demonstrated the remarkable influence that thickened tar and fatty substances had upon the resistance and the impermeability of building materials. Some great examples had been given in this respect of immersing in melted tar, at about 400° Fahr., some soft bricks that had been very successfully used in buildings destined to receive the chlorine gas when cemented with asphalte: some soft sandstone of Fontainbleau had been considerably hardened by this process; Champy, in 1813, had also preserved wood by injecting tar, in a similar manner, into the interstices and the channels of the wood.

On the occasion of the meeting of the Academy of Sciences on the 22d of June, M. Frederick Kuhlman read a second communication upon the same subject, in which he said that—

My opinion upon the part which I assigned to the tar, when it had penetrated the moulded plaster, and had been substituted for its water of hydration, has been confirmed by the following observations:—

When the water of hydration of the mineral matters can only be displaced at high temperatures, or when these matters are anhydrous, the tar infiltrates only into the fissures they present. I have proved this fact upon crystals of quartz, Iceland spar, rock salt, and upon

other anhydrous minerals unattackable at the degree of temperature at which the operation has been effected. When the crystals are fibrous and manifestly porous, like those of an agonite, stalactite, &c., the penetration is more intimate. I ought to mention on this occasion that a topaz and a rock crystal, the fissures of which had been penetrated by the tar, presented when looked at by transparency upon the thin edge of the coat of tar, a color of sombre garnet, analogous to that which is presented by smoked quartz, and sufficiently near that which glass melted under the influence of smoke would do, and which disappears by the addition of a little saltpetre. It must, however, be admitted that it is possible that this color may be owing to the properties of the tar when it is in the state of a very thin layer.

Upon a specimen of opal, submitted for a certain time to the action of boiling tar, I have proved that, independently of the infiltration of the tar through the fissures, the little water this stone loses is proved by a tint of smoked blue, a tint exactly like that of a variety of the opal of Mexico, which is to be found in the Museum of the School of Mines. This coloration of the opal merits the attention of mineralogists, for it was the paste itself which had been uniformly impregnated with bitumen, and had assumed colors which might be useful to jewellers. It seems to me, also, to throw some light upon the bituminous substances that are sometimes found in rock crystals. Gun-flints yielded similar results. When the flint is embedded in a pudding-stone composed of siliceous materials, the agglutinating material impregnates itself easily with the tar, whilst the color of the flint changes slightly.

When certain marbles which are very open in the grain, and are marked with decided veins, are submitted to the action of melting tar or other resinous or fatty substances, such as the onyx, &c., phenomena precisely analogous occur. The modifications of color, and the great consolidation that the marbles can derive from this operation, may be well employed in decoration.

It is not only the loss of the water of hydration that facilitates the penetration of the tar, or of the other resinous substances, into the mineral matters, but it may be also the loss of the other constituent parts of those matters. Thus, malachite, subjected to the action of boiling tar to a graduated temperature, is transformed—firstly into a black matter, in which the copper rests as an oxide, and which retains the ribbed and filamentary structure of the malachite. But the malachite, as also the azurite, are reduced and present themselves in the metallic state, when the temperature attains 520° or 570° Fahr. Copper which has been arseniated becomes fused at the same temperature, and gives off the arsenic that is carried away by the vapors of the tar. The carbonate of lead is reduced at still lower temperatures. One of the most clear results that I have obtained has been in the transformation, by means of the boiling tar, of the binoxide of manganese into the protoxide, without any change in the crystalline form of the binoxide, the tar having taken the place of the oxygen driven off for the benefit of the reducing body. The oxide of manganese, after the reaction, does not give any trace of chlorine by its contact with hydrochloric acid.

In all these reactions whether the tar displaces the water or some other principle constituting the minerals, or may intervene by penetrating only the fissures of the matters, it is important that the temperature of the tar should be gradually raised, so as not to produce a disruption of the bodies submitted to its action. This precaution is particularly necessary when it is required to submit to the melting tar articles in clay only dried in the air or in stoves, and which it may be desired to convert, in this manner, into impermeable pottery. When this heat is applied too briskly, the minerals and the clays are exposed to crack and to fly before the tar has had time to penetrate them.

By using the precaution that I have just indicated, I have obtained with clay moulded and dried, pottery which, independently of the very great economy of its production, is recommendable on account of its impermeability, its hardness, and its great resistance to acids. The application of this pottery to drain-pipes, tiles (both roofing and flooring), and an infinity of other objects that usually require economy of manufacture, seems to me susceptible of great extension, if I may judge by the results of the first trials made with a view to the success of these experiments, and which I have had the honor to submit to the Academy.

Renewing Worn-out Files.

From the London Builder, No. 1069.

A means of renewing worn-out files and rasps has been provisionally specified by Messrs. Kiesling, Liverpool. Grease and dust are removed by washing the files in warm water mixed with an alkali, say soda. They are then placed in a bath of clean water, to which, during a short time, and at intervals, nitric acid is added, and the files or the bath agitated. On removal from this bath they are placed in water, and brushed or rubbed over their surfaces. After adding to the acid bath another portion of nitric and some sulphuric acid, they are again put in and agitated. This is repeated several times; and, after sulphuric acid has again been added, and the files allowed to remain for a short time, they will be found, it is said, sufficiently sharp and fit, after being dried and oiled, for use.

For the Journal of the Franklin Institute.

On the Parabolic Construction of Ships. By John W. Nystrom, C. E.

The more I look into the Parabolic construction of ships, the more am I convinced that it is the true principle of naval architecture; for as far as the steps are mathematically proven, it agrees with that of the most accomplished constructors whose plans are empirically laid out; it ought to be adopted in every school of shipbuilding. The Parabolic method leads the constructor with certainty from beginning to end, and requires very little or no calculation; those who are not versed in mathematics need only employ the tables and scale.

In my last article on Parabolic construction, I mentioned something against hollow load water-lines, but the method naturally requires that lines hollow, although the theory of resistance does not, for the latter gives only the proportions of the ordinate cross-sections. I have also found that the hollow part of the water-line ought to commence where the ordinate is one-third of the beam, or $z = \frac{1}{3}\,b$, on which principle the following table for hollow water-lines is calculated from the formulas given on page 99 of the last volume of this *Journal*. Plate II. gives an appropriate idea of the sharpness for different exponents.

TABLE VIII.

PARABOLIC CONSTRUCTION OF SHIPS.

Expo.	ORDINATES OF HOLLOW WATER-LINES. $z = \frac{1}{3}\,b$.							AREA.	$s = l \times$
n	1	2	3	4	5	6	7	$a = BL \times$	
2	·1697	·3732	·5647	·7214	·8433	·9303	·9825	·6491	·3125
2·25	·1944	.4074	·6068	·7620	·8754	·9509	·9895	·6730	·3189
2·5	·1960	·4415	·6460	·7973	·9013	·9642	·9948	·6939	·3333
2·75	·2127	·4744	·6817	·8277	·9219	·9744	·9962	·7124	·3412
3	·2284	·5063	·7143	·8537	·9383	·9817	·9977	·7287	·3500
3·25	·2445	·5368	·7439	·8760	·9513	·9870	·9986	·7433	·3571
3·5	·2596	·5657	·7706	·8895	·9617	·9907	·9992	·7654	·3636
3·75	·2779	·5947	·7954	·9114	·9699	·9924	·9995	·7682	·3697
4	·2962	·6193	·8164	.9247	·9762	·9953	·9997	·7789	·3750
4·5	·3337	·6670	·8534	·9463	·9853	·9976	·9998	·7975	·3846
5·	·3744	·7105	·8839	·9619	·9909	·9988	·9998	·8139	·3929
5·5	·4081	·7465	·9070	·9727	·9944	·9994	·9999	·8269	·4000
6	·4428	·7790	·9260	·9806	·9965	·9997	·9999	·8385	·4062
6·5	·4703	·8266	·9405	·9860	·9978	·9998	1·0000	·8479	·4108
7	·5081	·8328	·9533	·9902	·9988	·9999	1·0000	·8582	·4166
8	·5861	·8794	·9719	·9953	·9994	1·0000	1·0000	·8730	·4250
9	·6186	·9047	·9815	·9975	·9998	1·0000	1·0000	·8852	·4318
10	·6606	·9274	·9883	·9992	·9999	1·0000	1·0000	·8942	·4375
12	·7415	·9601	·9954	·9997	1·0000	1·0000	1·0000	·9110	·4464
16	·8181	·9871	·9993	·9999	1·0000	1·0000	1·0000	·9319	·4629

In my former article it was also stated that the centre of gravity of the displacement in the length of the vessel is halfway between the middle of L and the dead flat $\mathcal{X}$, which is sufficiently correct in practice, and as correct as can be ascertained by the old empirical mode of calculation; nevertheless it is not mathematically correct, and the rule was given on the supposition that the exponent for the displacement should be the same fore and abaft, which is generally the case in all vessels; but constructors are not willing to bind themselves with rules that may not be congenial with their own taste, neither is that necessary, for the parabolic construction will accommodate any reasonable taste, and different exponents can be selected. The location of the centre of gravity is wholly dependent on the exponents of the displacement, for which it becomes necessary to seek the centres of gravity for the fore and aft parts separately, and find their common centre by the rule of static momentum.

The centre of gravity of any solid figure is found by the formula

$$s = \frac{\int x z \, dx}{v},$$

see Proposition VII, page 80, eighth edition, Nystrom's Pocket Book.

Applying this formula to the displacement we have z = the ordinate cross-section

$$\mathfrak{w} = \mathfrak{X}\left(1 - \frac{y^n}{l^n}\right)^2,$$

see page 319, same book, in which x takes the place of y, and D the place of v.

$$s = \frac{\int x p \, \mathfrak{w} \, x}{D} = \frac{\int x \mathfrak{X} \left(1 - \frac{x^n}{l^n}\right)^2 dx}{D}, \quad . \quad (1)$$

which gives the distance of the centre of gravity of the fore or aft part of the displacement from the dead flat $\mathfrak{X}$. In trimming this formula to a practical shape, let us first treat the integral in the numerator,

$$\left(1 - \frac{x^n}{l^n}\right)^2 = 1 - \frac{2x^n}{l^n} + \frac{x^{2n}}{l^{2n}} \text{ and}$$

$$\int \left(x \mathfrak{X} - \frac{2 \mathfrak{X} x^{n+1}}{l} + \frac{\mathfrak{X} x^{2n+1}}{l^{2n}} \right) dx = \frac{x^2 \mathfrak{X}}{2} - \frac{2 \mathfrak{X} x^{n+2}}{l^n (n+2)} + \frac{\mathfrak{X} x^{2n+2}}{l^{2n+2}},$$

in which x is limited to l, or $x = l$, and

$$\frac{l^2 \mathfrak{X}}{2} - \frac{2 \mathfrak{X} l^2}{n+2} + \frac{\mathfrak{X} l^2}{2n+2} = l^2 \mathfrak{X} \left(\frac{1}{2} - \frac{2}{n+2} + \frac{1}{2n+2} \right),$$

of which the factor in the parenthesis will be,

$$\left(\frac{2n^2}{4n^2 + 12n + 8} \right),$$

Collecting the dropped factors we have

$$s = \frac{l^2 \mathfrak{X}}{D} \left(\frac{2n^2}{4n^2 + 12n + 8} \right), \quad . \quad . \quad (2)$$

The formula for the displacement D, page 255, last volume of this Journal, is,

$$D = \frac{\mathfrak{X} l \, 2n^2}{2n^2 + 3n + 1},$$

which is inserted in formula 2, will be,

$$s = \frac{l^2 \mathfrak{X} (2n^2 + 3n + 1)}{\mathfrak{X} l \, 2n^2} \left(\frac{2n^2}{4n^2 + 12n + 8} \right), \text{ or}$$

$$s = \frac{l}{4} \left(\frac{2n^2 + 3n + 1}{n^2 + 3n + 2} \right), \quad . \quad . \quad (3)$$

which is the finished formula for the centre of gravity, n is the exponent for the displacement marked n'' in the former article, and l the distance from $\mathfrak{X}$ to the stem or stern, when s will be the distance from $\mathfrak{X}$ to the centre of gravity. The factor in the parenthesis divided by 4, is calculated for twenty exponents and contained in the last column

table VIII, and the centre of gravity is obtained simply by multiplying this number into the length.

When the centres of gravity are thus found for the two parts of the whole displacement, the common centre is found by their static momentum, for which letters denote, s = distance from the stern to the common centre of gravity of the whole displacement, D. s and l for the aft part a, and s' and l' for the fore part d of the displacement,

$$\text{we have } \mathrm{s}\,\mathrm{D} = \mathrm{a}(l-s) + \mathrm{d}(l+s'), \text{ and}$$

$$\mathrm{s} = \frac{\mathrm{a}(l-s)+\mathrm{d}(l+s)}{\mathrm{D}}, \quad . \quad . \quad (4)$$

When the exponents n'' are alike fore and aft, the formula (4) will become

$$\mathrm{s} = \frac{l(l-s)+l'(l+s')}{\mathrm{L}}, \quad . \quad . \quad (5)$$

Now let us apply this formula to the propeller steamer described on page 105, last volume of this Journal, and we will see how much it differs from the approximate rule.

The exponent $n'' = 2$, fore and aft, $l = 65{\cdot}625$, and $l' = 84{\cdot}375$ feet, when $s = 0{\cdot}3125 \times 65{\cdot}625 = 20{\cdot}51$, and $s' = 0{\cdot}3125 \times 84{\cdot}375 = 26{\cdot}37$ feet, L = 150.

$$\mathrm{s} = \frac{65{\cdot}625\,(65{\cdot}625 - 20{\cdot}51) + 84{\cdot}375(65{\cdot}625 + 26{\cdot}37)}{150} = 71{\cdot}49 \text{ feet.}$$

This is the correct distance of the centre of gravity of the whole displacement from the stern; by the approximate rule it will be 70·312 feet, or about one foot difference.

The depth of the centre of gravity of displacement cannot be found theoretically correct by a direct formula, on account of its dependence so much on the constructor's taste in shaping the ordinate cross-sections. The formula (11), page 99 last volume of this Journal, is only approximative, but sufficiently correct in practice; if the ordinate cross-sections were parabolas of different orders, we could easily find the desired formula by Proposition V, page 80, eighth edition of Nystrom's Pocket-Book.

$$e = \frac{\int x\,y\,dx}{z},$$

in which x takes the place of y, $y = b - x$, and $\mathfrak{X} = z$ in the parabolic section, or,

$$e = \frac{\int y\,(b-x)\,dy}{\mathfrak{N}}, \quad . \quad . \quad (6)$$

in which $x = \frac{y^n b}{l^n}$, and $\mathfrak{X} = \frac{b\,l\,n}{n+1}$, inserted in formula (6), will be

$$e = \frac{(n+1)\int y\left(b - \frac{y^n b}{l^n}\right)dy}{b\,l\,n} = \frac{(n+1)\int\left(y - \frac{y^{n+1}}{l^n}\right)dy}{l\,n}.$$

The integral

$$\int\left(y-\frac{y^{n+1}}{l^n}\right)dy=\frac{y^2}{2}-\frac{y^{n+2}}{l^n(n+2)},$$

but y is limited to l, which is the depth d in the cross section $\mathcal{N}$,

$$\int=\frac{d^2}{2}-\frac{d^{n+2}}{d^n(n+2)}=\frac{d^2n}{2(n+2)}, \text{ and}$$

$$e=\frac{(n+1)d^2n}{d\,n\,2(n+2)}=\frac{d}{2}\left(\frac{n+1}{n+2}\right), \quad . \quad . \quad (7)$$

which gives the depth e of the centre of gravity under the water-line of parabolic cross-sections of any order. From this formula we find the exponent

$$n=\frac{4e-d}{d-2e}, \text{ and we have}$$

$$\mathcal{N}=\frac{b\,d\,n}{n+1}, \text{ of which } n=\frac{\mathcal{N}}{b\,d-\mathcal{N}},$$

$$\text{or, } \frac{4e-d}{d-2e}=\frac{\mathcal{N}}{b\,d-\mathcal{N}}, \text{ from which}$$

$$e=\frac{b\,d^2}{2(2bd-\mathcal{N})}, \quad . \quad . \quad (8)$$

which also gives the depth of the centre of gravity under the water-line of parabolic ordinate cross-sections. The formula (8) treated by the calculus will give the depth of the centre of gravity of the whole displacement, but a very complicated process which is preferred to be herein avoided, when the following fortunate idea will solve the problem correctly. Let us denote by Σ the mean effect produced in the progress of any variable quantity, as $\Sigma\,b$ is the mean effect of b, inserted in the formula (8) will be

$$\Sigma\,e=\frac{d^2\,\Sigma\,b}{2(2\,d\,\Sigma\,b-\Sigma\,\mathcal{N})}, \quad . \quad . \quad (9)$$

When the variable quantities b and $\mathcal{N}$ progress throughout the displacement, they will produce

$$\Sigma\,b=\frac{n}{n+1}, \text{ and } \Sigma\,\mathcal{N}=\frac{\mathrm{D}}{b\,d\,l},$$

$$\mathcal{N}=\frac{b\,d\,n'}{n'+1}, \text{ and } \mathrm{D}=\frac{\mathcal{N}\,l\,2n''^2}{2n''^2+3n''+1}.$$

Let us further designate.

$$\mathbf{a}=\frac{n}{n+1}, \mathbf{b}=\frac{n'}{n'+1}, \text{ and } \mathbf{c}=\frac{2n''^2}{2n''^2+3n''+1},$$

we have **a** and **b** contained in next to the last column, Table VI, page 252, last volume of this Journal; but when the water-line is hollow, **a** must be taken from the next to the last column, Table VIII, page 390; **c** is contained in next to the last column, Table VII, page 252.

$$\Sigma \mathcal{M} = \frac{\mathrm{D}}{b\,d\,l} = \frac{\mathcal{M}\,\mathbf{c}}{b\,d} = \frac{b\,d\,\mathbf{b}\,\mathbf{c}}{b\,d} = \mathbf{b}\,\mathbf{c},$$

the depth of the centre of gravity of the whole displacement $e = \Sigma e$ will then be

$$e = \frac{d\,\mathbf{a}}{2(2\,\mathbf{a} - \mathbf{b}\,\mathbf{c})}, \qquad . \qquad . \qquad (10)$$

which formula is theoretically correct, on the supposition that the ordinate cross-sections are parabolas, as is most generally the case in ordinary vessels.

Let us apply this formula to the propeller steamer described on page 105 of the last volume, and we will see how much it differs from the approximate rule by formula 11, page 99, same volume.

We have given, $l = 65{\cdot}625$, $l' = 84{\cdot}375$, $\mathbf{a} = 0{\cdot}7142$ for the exponent $n = 2\frac{1}{2}$ full lines, Table VI, and $\mathbf{a}' = 0{\cdot}6491$ for the exponent $n = 2$, hollow lines, Table VIII.

$$\mathbf{a} = \frac{l\,\mathbf{a} + l'\,\mathbf{a}'}{\mathrm{L}} = \frac{65{\cdot}625 \times 0{\cdot}7142 + 84{\cdot}375 \times 0{\cdot}6491}{150} = 0{\cdot}6776.$$

$\mathbf{b} = 0{\cdot}75$ exponent $n' = 3$ Table VI.

$\mathbf{c} = 0{\cdot}53333$ exponent $n'' = 2$ Table VII.

$d = 15$ feet, draft of water.

$$e = \frac{15 \times 0{\cdot}6776}{2(2 \times 0{\cdot}6776 - 0{\cdot}75 \times 0{\cdot}5333)} = 5{\cdot}376 \text{ feet.}$$

The approximate rule gives $e = 5{\cdot}04$ feet, which is a difference of 0·33 feet, or 4 inches from the true parabolic rule. The old complicated and laborious rule for finding the centre of gravity, can be applied first when the vessel is constructed, and then gives only an approximate result.

Should the vessel not be constructed by the Parabolic method, or the exponents not being known, the depth of the centre of gravity, e, may be found from the following formulæ, deduced from formula 10, namely,

$$e = \frac{d}{2\left(2 - \frac{\mathrm{D}}{\mathbf{a}\,d}\right)}, \qquad . \qquad . \qquad (11)$$

in which $\mathbf{a}$ denotes the area of the load water-line in square feet, d = draft of water, and D = displacement in cubic feet.

To find the Ratio of the Displacement.—The ratio of the displacement denoted by the letter r, is the increase of bulk from the keel to the load-line; the ratio determines the displacement at different drafts, or the draft of water at different displacements. Let us form the displacement into a parallel prism of the breadth $\Sigma\,\mathrm{B}$ in the load-line and of the cross-section $\Sigma\,\mathcal{M}$, for which the ratio is easily found. In the parabolic formulæ the ratio r takes the place of the exponent n, and we know that

$$\mathfrak{N}=\frac{\text{B}\,dr}{r+1}, \qquad r=\frac{\mathfrak{N}}{\text{B}\,d-\mathfrak{N}}, \qquad \text{or } \Sigma\, r=\frac{\Sigma\,\mathfrak{N}}{d\,\Sigma\,\text{B}-\Sigma\,\mathfrak{N}},$$

in which $\Sigma\,\mathfrak{N}=\frac{\text{D}}{\text{L}}$, and $\Sigma\,\text{B}=\frac{\mathbf{a}}{\text{L}}$,

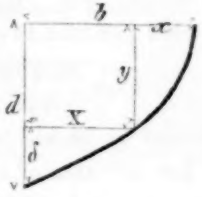
which gives the mean ratio of the displacement

$$r=\frac{\text{D}}{d\mathbf{a}-\text{D}}, \qquad . \qquad . \qquad (12)$$

Example 1.—Let the area of the load water-line of a vessel be $\mathbf{a}=3193{\cdot}58$ square feet, draft of water $d=15$ feet, and displacement $\text{D}=26998$ cubic feet, we have the ratio

$$r=\frac{26998}{15\times 3193{\cdot}58-26998}=1{\cdot}29.$$

Let the accompanying figure represent half the $\Sigma\,\mathfrak{N}$ of the assumed prismatic displacement, d = load draft, δ any other draft for the water-line X, then the area of any immersed section at the draft δ will represent the displacement, and X the area of that water-line. From the parabolic formula we have



$$x=\frac{y^r b}{d^r}, \quad \text{X}=b-x, \text{ and } y=d-\delta.$$

The increment of the immersed area $\mathfrak{N}$ or displacement D, counted from the keel will be,

$$\mathfrak{d}\mathfrak{N}=\text{X}\,\mathfrak{d}\delta=(b-x)\,\mathfrak{d}\delta=\left(b-\frac{y^r b}{d^r}\right)\mathfrak{d}\delta=\left(b-\frac{b}{d^r}(d-\delta)^r\right)\mathfrak{d}\delta.$$

$$\mathfrak{N}=\int\left[b-\frac{b}{d^r}(d-\delta)^r\right]\mathfrak{d}\delta=b\,\delta-\frac{b}{d^r}\int(d-\delta)^r\,\mathfrak{d}\delta,$$

call $d-\delta=z$, and we have $\mathfrak{d}\delta=-\mathfrak{d}z$.

$$\int -z^r\,\mathfrak{d}z=-\frac{z^{r+1}}{r+1}=-\frac{(d-\delta)^{r+1}}{r+1}, \text{ and}$$

$$\mathfrak{w}=b\delta+\frac{b\,(d-\delta)^{r+1}}{d^r(r+1)}+\text{C}.$$

Let $\delta=0$, when $\mathfrak{w}$ will be 0 also, and the value of C will be

$$\text{C}=-\frac{b\,d}{r+1}, \text{ and}$$

$$\mathfrak{w}=b\left[\delta+\frac{(d-\delta)^{r+1}}{d^r(r+1)}-\frac{d}{r+1}\right].$$

$$\mathfrak{w}:\Sigma\,\mathfrak{N}=\text{D}:\text{D}, \text{ but } \Sigma\,\mathfrak{N}=\frac{\text{D}}{\text{L}}, \text{ and } \Sigma\,\text{B}=\frac{\mathbf{a}}{\text{L}}.$$

$$\mathfrak{w}:\frac{\text{D}}{\text{L}}=\text{D}:\text{D}, \text{ and } \mathfrak{w}=\frac{\text{D}\,\text{D}}{\text{L}\,\text{D}}=\frac{\text{D}}{\text{L}}.$$

$$\mathfrak{w}=\frac{\text{D}}{\text{L}}=\Sigma\,\text{B}\left[\ldots\right]=\frac{\mathbf{a}}{\text{L}}\left[\ldots\right] \text{ and } \text{D}=\frac{\mathbf{a}}{\text{L}}\,\text{L}\left[\ldots\right],$$

and we arrive at the final formula for the displacement at any draft δ to be

$$\text{D} = \mathbf{a}\left(\delta + \frac{(d-\delta)^{r+1}}{d^r(r+1)} - \frac{d}{r+1} \right). \quad . \quad (13)$$

EXAMPLE 2.—Required the displacement $\text{D} = ?$ of a vessel of the dimensions as in Example 1, at $\delta = 9{\cdot}836$ feet draft of water.

$$\text{D} = 3193{\cdot}58\left(9{\cdot}836 + \frac{(15-9{\cdot}836)^{2{\cdot}29}}{15^{1{\cdot}29}(1{\cdot}29+1)} - \frac{15}{(1{\cdot}29+1)} \right) = 11816{\cdot}246$$

cubic feet, divided by 35, will be $t = 337{\cdot}6$ tons, the answer.

The displacement scale is constructed by formula 13.

Differentiating the formula 13 we have,

$$\delta\text{D} = \mathbf{a}\,\delta\delta\left[1 + \left(\frac{d-\delta}{d} \right)^r \right]. \quad . \quad . \quad (14)$$

EXAMPLE 3.—Required how much $\delta\text{D} = ?$ the same vessel can be loaded per inch $\delta\delta = \frac{1}{12}$ foot at a draft of water $\delta = 12$ feet.

$$\delta\text{D} = \frac{3193{\cdot}58}{12}\left[1 + \left(\frac{15-12}{15} \right)^{1{\cdot}29} \right] = 233 \text{ cubic feet,}$$

divided by 35 will be $t = 6{\cdot}66$ tons.

Let $a =$ area of any water-line at the draft δ, we have

$$a = \mathbf{a}\left[1 - \left(\frac{d-\delta}{d} \right)^r \right]. \quad . \quad . \quad (15)$$

Proceedings of the Association for the Prevention of Steam Boiler Explosions, Manchester.

From the Journal of the Society of Arts, No. 550.

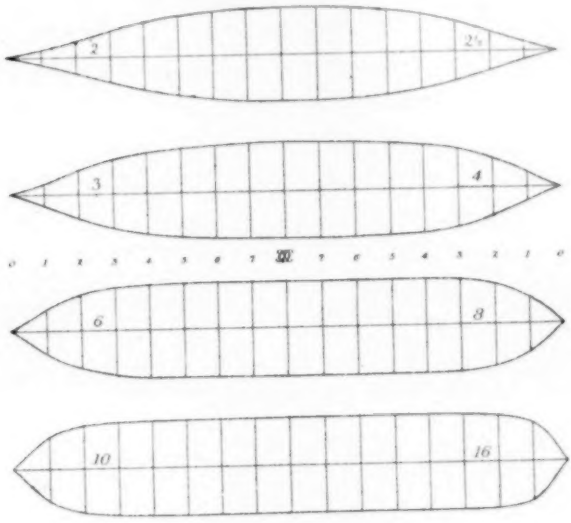
[Report of the Chief Engineer March 31st, 1863.]

During the past month, there have been examined 370 engines—1 specially; 492 boilers—6 specially, 17 internally, 60 thoroughly, and 409 externally, in which the following defects have been found;—Fracture, 2 (1 dangerous); corrosion, 18 (2 dangerous); safety valves out of order, 4; water gauges ditto, 24 (1 dangerous); pressure gauges ditto, 16; feed apparatus ditto, 5; blow-off cocks ditto, 47 (1 dangerous); fusible plugs ditto, 5; furnaces out of shape, 3 (1 dangerous): over-pressure, 2; deficiency of water, 2; blistered plates, 2. Total, 130 (6 dangerous). Boilers without glass water gauges, 1; without pressure gauges, 1; without blow-off cocks, 36; without back pressure valves, 58.

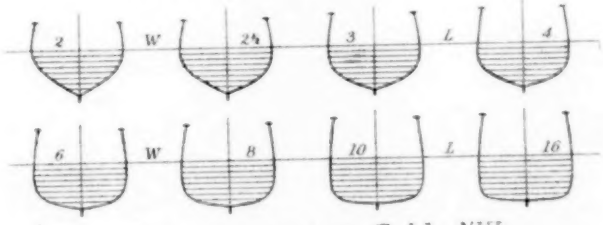
Explosions.—It will be remembered that in last month's report no detailed particulars were given of No. 1 explosion, which occurred to a boiler not under the inspection of this Association, and which was of the double furnace, internally fired class. Particulars have, however, been since obtained, and show that the explosion was of a very simple character. It was the practice to keep up a fire in this boiler

PARABOLIC CONSTRUCTION OF SHIPS

Hollow Waterlines Table VIII



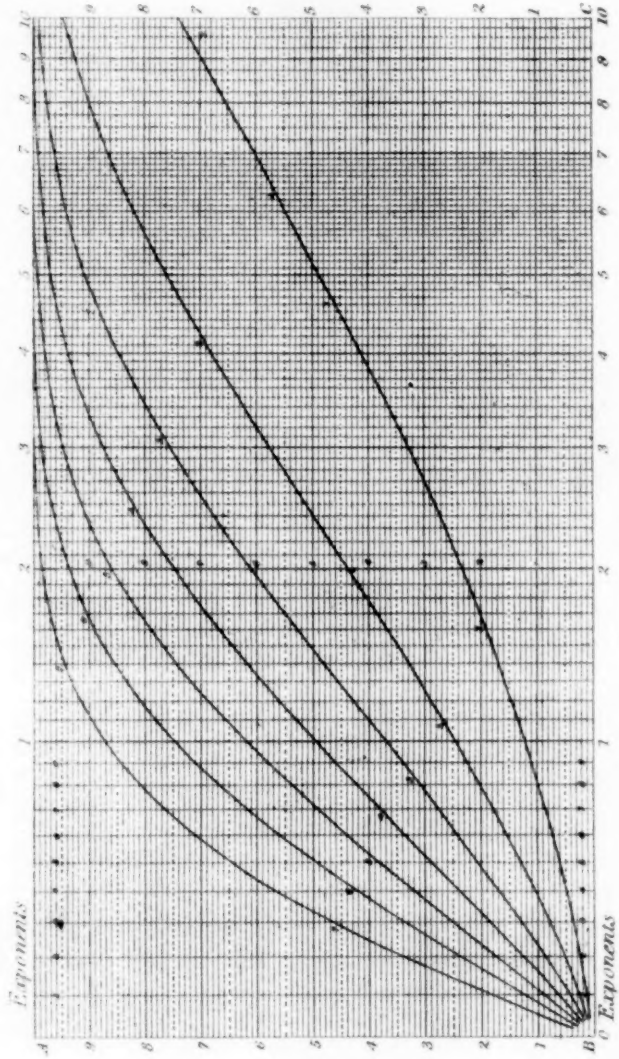
Cross-sections Table I



Cross-sections Table VIII

T. Sinclair's lith. Ph

PARABOLIC CONSTRUCTION OF SHIPS



throughout the night, for the purpose of heating the mill, and a boy was left in charge to attend to it. The demand made upon the boiler for steam was such that no supply of water would carry it through the night, and therefore it was the duty of the attendant to make up the deficiency with the donkey pump. This, however, he neglected to do, in consequence of which the furnace crowns were laid bare, the plates became red hot, and collapse ensued. The boy was absent from the boiler at the time of the explosion, neither was any one else near it, and thus happily no lives were lost nor any one injured, while the damage to property was confined to that done to the boiler itself.

This is just one of those cases in which a low-water safety valve would have been of service, not only by its giving an alarm before the furnace crowns were laid bare, but also by letting off the pressure of steam.

Two explosions have occurred during the past month to boilers not under the inspection of this Association, by which 15 persons were killed, and 16 others injured, making a total of 31. Both boilers have been personally examined subsequent to the explosion. The following is the monthly tabular statement:—

Index No.	Date.	General Description of Boiler.	Persons killed.	Persons injured.	Total.
No. 4,	Feb. 23,	Vertical Iron Works Boiler, Internally fired, . .	13	15	28
No. 5,	March 17,	Ordinary double flue, or "Lancashire." Internally fired, .	2	1	3
		Total, . . .	15	16	31

No. 4 explosion occurred at an iron works, to a boiler connected to a series of eighteen others. It was very similar in general construction, though not precisely so, to those known as upright furnace boilers, like which, it stood erect, was of considerable height, and surrounded with brick-work. They, however, are heated by the flames passing off from the iron furnaces, which play first upon the outside of the shell, then pass through openings in the side into an internal descending flue, and escape to the chimney; while the boiler in question had its own independent furnace, placed in the internal flue, which was thus converted from a descending to an ascending one, the openings at the side becoming outlets for the flame instead of inlets. The top of the boiler was hemispherical, and the bottom flat; whereas in the ordinary furnace class, both ends are hemispherical, which is an important difference.

The boiler was 20 feet high, and about 9 feet 6 inches diameter. The internal fire-box was 10 feet high, 4 feet 6 inches diameter at the crown, and also for about the first 3 feet 6 inches below; from which point it tapered outwards to a diameter, at the bottom, of 6 feet 6 inches

leaving an annular water space all round, about 18 inches in width, between it and the shell. This fire-box was united to the shell at the bottom, by a flat plate connected by rings of angle iron inside the water space. The crown of this internal fire-box was slightly domed, and flanched at its attachment to the cylindrical sides, being amply stiffened by six angle irons laid across and well riveted to it. At the upper part of the fire-box, were the two outlets previously referred to, and which were formed by short transverse flues passing through the water space, and thus establishing a communication between the internal furnace and the external flue. These short flues, which were opposite one to the other, and at right angles to the furnace door, were 2 feet 6 inches in diameter, and attached by rings of angle iron at each end.

The thickness of the plate was: in the hemispherical end and cylindrical sides of the external shell, three-eights of an inch: in the flat plate at the bottom of the water space, seven-sixteenths: while all the angle irons were 3 inches by 3 inches and half an inch thick. In the fire-box the thickness of the crown plate was half an inch, and that of the sides seven-sixteenths.

With regard to the lay of the plates, that in the shell was according to the usual plan, being radial in the hemispherical end, and circumferential in the cylindrical sides, the seams in the latter breaking joint; while in the taper portion of the fire-box, the plates were laid longitudinally, and thus, which it is important to notice, the seams were in line for a length of between six and seven feet. The riveting was single throughout, and the seams were the ordinary overlap.

The boiler had been fitted with a float, two gauge taps, one feed stop valve, one feed back-pressure valve, and one lever-safety valve of 5 inches diameter, which was loaded to a pressure of nearly 50 pounds, and at all events would have allowed the steam to have reached that pressure when blowing off freely. Also there were two junction valves, one of which was in the steam-pipe communicating with the entire series of boiler, and the other in that connected to the steam hammer. There was no steam pressure-gauge on the boiler itself, but one was fixed to the main steam pipe beyond the junction valve, and thus afforded no indication of the pressure of the steam within the boiler, when it was shut off from the others in the series. Both of the junction valves were closed at the time of the explosion, and thus the safety-valve formed the only outlet for the steam. What the pressure then rose to cannot now be ascertained, the steam pressure gauge as just pointed out, giving no indication under such circumstances. The safety-valve, however, was found to be free after the explosion, and there is no reason to conclude that it had been otherwise previously. But it is apparent from this how circumstances will arise which make it important that every boiler should be fitted with a duplicate safety-valve, as well as with its own independent pressure-gauge.

A very general impression exists that the cause of most, if not of all the explosions that occur at iron works, is to be found in the old age and dilapidated condition of the boilers; such, however, was not

the case in this instance; the workmanship of the boiler was satisfactory throughout, and its condition good. It was reported to have been at work only a few months, which its appearance corroborated. Were all boilers in as good condition as this one was, explosions would be of much rarer occurrence than at present.

The cause of this explosion was not "shortness of water;" the crown of the fire-box was uninjured, the color of the plate black, a thin scale covering portions of it, while the rents made in the boiler were not those which a deficiency of water would have occasioned.

A serious oversight had been made in the design of the boiler, the top end being hemispherical and the bottom flat. The hemispherical end would, when the steam was fully up, and blowing off freely, have an upward pressure nearly of 250 tons acting upon it and tending to tear it away from the bottom. There would be an equal downward strain counteracting this, induced by the pressure of the steam upon the crown and tapering sides of the fire-box, combined with that upon the flat plate forming the bottom of the annular water space. As long as the attachment between the bottom and the top of the boiler held good, the two forces would be in equilibrio, and the boiler remain at rest upon its bed. But should the attachment fail, the upward force would instantly shoot the top of the boiler up into the air with a buoyancy of 250 tons, which it may be remarked, is equal to the weight of a long railway train, including the engine and tender fully equipped with coke and water. This action is exactly what took place. The flat plate at the bottom gave way, rending completely round through the seam of rivets, at the outside ring of angle iron which attached it to the shell; when the boiler flew up and was carried to a distance of 160 yards from its original seat. The brick-work at the top of the chimney was shaken, and there were marks or violence on the crown of the boiler, so that it is possible that it struck the top of the chimney in its course. There is nothing surprising in this, when the amount of the pent-up force of steam within so large a boiler is considered, and the due appreciation of which shows how unnecessary is the supposition of the existence of explosive gaseous compounds, or any force greater than that of the steam itself; while the propagation of such theories only tends to divert attention from the real cause of steam boiler explosions. The rent at the flat bottom plate however was by no means the only one that was made. The short transverse flues passing through the water space, and which considerably assisted the bottom plate, also gave way, and were torn from both the shell and fire-box, their mode of fracture giving unmistakeable evidence of the upward flight of the shell. The resistance of these flues to fracture, had severed the fire-box in the waist at the ring seam of rivets, at which the longitudinal plating terminated; and thus the fire box crown, as well as one ring of plates with the two short flue tubes, had flown up together with the shell, which made a somewhat remarkable and complicated feature in the development of the rents. Added to this, the remaining portion of the fire-box, which was taper, and placed longitudinally, rent at one of the longitudinal seams opposite the fire door, and collapsed at that part.

Some difference of opinion has existed amongst the engineers who have examined the boiler, as to whether the explosion originated at the rent of the flat bottom plate, or at the collapse of the fire-box. Though there may be some difficulty in determining which was the weaker spot of the two, there has been none in deciding that the boiler was inherently defective; and the opinion has been unanimous that there is no evidence for attributing the explosion either to "shortness of water" or excessive pressure, but that it was clearly owing to the malconstruction of the boiler itself. It may be added that the application of the hydraulic test would have detected and exposed the weakness both of the fire-box and bottom flat plate, the former, by its temporary flattening, the latter by the movement and rising of the outer shell.

The jury at the coroner's inquest came to the following conclusions, which are quite in accordance with the preceding report:—"That the explosion was caused by the bad construction of the boiler; that every boiler ought to be supplied with a steam pressure-gauge; and that no new boiler ought to be put to work before it has been examined by some competent engineer and pronounced to be safe."

No. 5 Explosion, occurred to one of two mill boilers working side by side and connected together, both being of the plain double-flued, internally-fired class, termed "Lancashire."

The length of the one in question was 28 feet, the diameter of the shell 10 feet, and that of the flues, which were parallel throughout their whole length, 3 feet 9 inches; the thickness of the plates were seven-sixteenth in the shell, and three-eights in the flues. The boiler had been fitted with one glass water-gauge, one feed back-pressure and stop-valve combined, one blow-out tap, one lever safety-valve, and one Schaeffer steam pressure-gauge, common to both boilers. The pressure at which the safety-valve was stated by the engine attendant to have blown off, was 30 lbs. on the square inch, which an examination of its dimensions, lever and weights corroborated.

On examining the boiler it was found that the right-hand flue had collapsed from one end to the other, and by the flattening action had become severed completely in two at some of the ring seams of rivets, as well as torn away from the end plate at the back of the boiler. The boiler had not stirred from its original position, and the connexions to the one alongside remained unbroken.

The rush of water, however, from the opening at the back, had blown up the brick flue and carried away the end wall of the boiler-house, in consequence of which a floor above, as well as some cast iron girders by which it had been supported, were brought down. It was by the fall of the building that the three men received their injuries, one was found to be dead when dug out of the *debris*. At the front end of the boiler the furnace mountings had been blown off.

The amount of damage done to the surrounding property was comparatively inconsiderable, and this is generally found to be the case where explosions is confined to collapse of the internal flues. Where, however, the external shell gives way, the consequences are much

more serious. The boiler does not then remain quietly in its seat as it did in the present instance, but—to the effect of the percussive action of the steam, which was the only element of injury in this case —adds that of the flight of the fragments of the shell, as in the preceding No. 4 explosion, as well as in the one that occurred to an iron-works boiler in December last, the particulars of which were given in the report for that month.

With regard to the cause of the collapse, there was no evidence of "shortness of water," judging from the appearance of the plates; added to which, the other furnace in the same boiler remained unaltered in shape, which could not have been the case had deficiency of water occurred: while, in addition, it appeared that the collapse of the flue had commenced at the middle of its length, and not over the furnace, where the shape was less distorted than at any other part.

The collapse cannot be fairly attributed to "shortness of water," but its true cause will be found in the construction of the flue, which was not strengthened with flanched seams or the addition of any hoops. Such a flue as the present, of so large a diameter as 3 feet 9 inches, and 28 feet long, made of plate only three-eights thick, is not safe for regular work with steam at a pressure of 30 lbs. per square inch, as was the case in this instance. It might work for a time, but still there would be a risk, as the event proves; a risk that might have been avoided had the flue been strengthened with any of the approved methods, namely, flanched seams, or hoops, either of angle iron, T iron, bridge rail section, or any other suitable form; to the importance of which attention has been called, it is feared with tedious frequency, though an apology for so doing, it is thought, may be found in the repeated occurrence of such explosions as the present, and in the loss of life consequent upon them.

It may be here added, there is every reason to conclude that the boiler in question was an illustration of the danger referred to in previous reports, arising from internal flues being actually oval, although supposed to be circular. The angle iron rings at the end plates were circular, but the inclination of the axis of the collapse of the flue indicated that the middle portion had been oval. The other flue alongside was evidently so, and had, in consequence, been strengthened by two stays attached to the crown. The flues of all of the boilers under inspection of the Association are gauged to ascertain their actual shape, when the members allow an opportunity of making "thorough examination," without which it cannot be done; and very numerous are the instances in which flues, previously supposed to be circular, are found on actual measurement to be oval.

This explosion is one that must be added to the category of those caused by malconstruction of the boiler, and cannot be termed accidental. The application of the hydraulic test would have detected the weakness, and the adoption of any of the approved methods of strengthening flues mentioned above, prevented the explosion. These preventives have now become common knowledge, they can be applied at little expense, and by any ordinarily competent boiler maker, and

thus are within the reach of all. It may therefore be fairly pointed out that their rejection by one manufacturer is an act of injustice to others, since nothing can operate more directly to induce government interference with the present unfettered use of steam, than the frequent occurrence of loss of life through the neglect of precautions so simple as those just alluded to.

For the Journal of the Franklin Institute.

On a New System of Arithmetic and Metrology, called the Tonal System. By JOHN W. NYSTROM, C. E.

(Continued from page 348.)

In the ordinary application of mathematics to metrology, it would be best to establish certain notations for the different units to be employed in algebraical formulas and as abbreviation in writing, which would greatly relieve the present confusion and repetition of meaning of letters.

Abbreviation of Tonal Units.

M = *Metre*, unit of length.
G = *Gall*, unit for capacity.
T = *Tim*, unit for time and the circle.
P = *Pon*, unit for weight.
H = *Horse power*, unit for work.
D = *Dollars*, unit for money.
Tp = *Temp*, unit for heat.

The abridgment of the units to be noted by capital letters, and the multiplication and division of the same to be noted by small letters placed before or after the units, thus: Mt. = metons, tM. = tonmetres, Gs. = Gallsans, Ts. = timsans, mP. = millpons, &c., &c.

EXAMPLE 11.—When 3ℓ9P of butter cost 4·38D, how much will 1ℓ·2ℭP of the same cost.

$$3ℓ9 : 1ℓ·2ℭ = 4·38 : X$$

$$X = \frac{1ℓ\,2ℭ \times 4·38}{3·ℓ9} = 1ℭ·36 \text{ dollars.}$$

1ℓ·2ℭ		3·ℓ9)	72·9910 (1ℭ·36
4·38			3ℓ9 . . .
8ℓ70			3609 . .
5189			350ℓ . .
6ℓ8			
72·9910			ℓℓ1 .

The answer is 1ℭ dollars, 3 shillings and 6 cents.

EXAMPLE 12.—What will be the interest on 3ℭℓ8·65D in 4 years and 5 months, at 9 per sant per annum? (9 per sant is about 6 per cent. decimal.)

Interest $= 3\mathcal{Z}\mathcal{E}8{\cdot}65 \times 0{\cdot}09 \times 4{\cdot}5 = 953{\cdot}82$ dollars.

Example 13.—A yearly payment or annuity of $3\mathcal{Z}\mathcal{E}{\cdot}65$D is standing for 15 years and $\mathcal{E}$ months,—what will it amount to in that time at $\mathcal{E}$ per sant interest?

Amount $= 3\mathcal{Z}\mathcal{E}{\cdot}65 \times 15{\cdot}\mathcal{E}\left[1 + \frac{0{\cdot}0\mathcal{E}}{2}\ (15{\cdot}\mathcal{E} + 1)\right] = 884\mathcal{f}{\cdot}\mathcal{E}\mathcal{Z}$ dollars.

$3\mathcal{Z}\mathcal{E}{\cdot}65$	$1\mathcal{V}{\cdot}\mathcal{E}$	5473·127
$15{\cdot}\mathcal{E}$	0·0058	$1{\cdot}5\mathcal{E}\mathcal{E}8$
244357	$\mathcal{Z}58$	29358538
135883	$8\mathcal{f}7$	$3\mathcal{f}564\mathcal{Z}\mathcal{E}4$.
$3\mathcal{Z}\mathcal{E}65$		$445\mathcal{E}7\mathcal{Z}\mathcal{f}\mathcal{E}$ . .
5473·127	0·5$\mathcal{E}\mathcal{E}$8	$2\mathcal{f}50\mathcal{E}95\mathcal{f}$ . . .
		5473127 . . . .

The required amount will be $\$884\mathcal{f}{\cdot}3\mathcal{Z}96178$

Example 14.—When one gall. of fresh water weighs one pon, how much will $5{\cdot}\mathcal{E}\mathcal{Z}$ cubic metres of cast iron weigh, when the specific gravity of the iron is 7·212?

Weight $7{\cdot}212 \times 5{\cdot}\mathcal{E}\mathcal{Z} = 25{\cdot}\mathcal{E}463\mathcal{V}$ Pons, the answer.

A similar example by the old system will be very complicated. Even in the French metrical system there is more confusion in pointing off the decimals.

Example 15.—A locomotive running $39{\cdot}\mathcal{Z}^{m}$M per *Tim*, leaves London at $5{\cdot}\mathcal{E}4$T; another locomotive on the same track makes $6\mathcal{Z}{\cdot}\mathcal{V}^{m}$M per *Tim*, leaves London at $6{\cdot}2\mathcal{V}$T. At how many Millmetres from London, and at what time will the faster locomotive reach the other?

The time of the fast locomotive will be,

$$T = \frac{39{\cdot}\mathcal{Z}\ (6{\cdot}2\mathcal{E} - 5{\cdot}\mathcal{E}4)}{6{\cdot}\mathcal{Z}\mathcal{V} - 39{\cdot}\mathcal{Z}} = 0{\cdot}7 \text{ tims, the answer.}$$

and $6.2\mathcal{V} + 0{\cdot}7 = 6{\cdot}5\mathcal{E}$ tims, the time when the fast locomotive reaches the other. Distance from London will be $6\mathcal{Z}{\cdot}\mathcal{V} \times 0{\cdot}7 = 30{\cdot}74$ Millmetres.

Examples in Navigation, Comparing the Old and Tonal Systems.

Example 16.—In the year 1861 the sun's declination at Greenwich mean noon is:

	Old System.		Tonal System.
March 13,	2° 48′ 36·9″	=	0·1$\mathcal{f}\mathcal{f}$9 tims.
March 14,	2° 27′ 57·3″	=	0·1$\mathcal{V}$7$\mathcal{E}$ "
Difference,	23′ 39·6″	=	0·047$\mathcal{E}$ "

Required the true declination of mean noon, on the 13th of March, 1861, in longitude west from Greenwich, 156° 40′ 23″ = 6·f705 tims = 0·6f705 days.

Old System.

0·4353	156°	360
23 Mult.	60 Mult.	60 Mult.
13059	9360	21600 Min.
8706	42 Add	60 Mult.
10·0119 Min.	9402 Min.	1296000 Sec.
	60 Mult.	
0·0119	564120	
60 Mult.	23 Add	
0·7140	564143 Seconds.	
Add 39·6 Seconds.		
40·3140		
40·314		
0·4353		
120942		
201570 .		
120942 . .		
161256 . . .		
17·5486842 Seconds.		

564143·0000 | 1296000
5184000 . . . | 0·4353
4574300 . .
3888000 . .
6863000 .
6480000 .
3830000
3888000

from which the correction will be 10′ 17·548″.

Tonal System.

Diff. longitude	0·6f705 days.
Diff. declination	0·047ε tims.
	5ι0ε75
	36f13f
	1ιεf24
Correction	0.01f93465 tims.

The required declination will be.

	2° 48′ 36·9″ = 0·1ff9 tims.
Correction, add	10′ 17·5″ = 0·01f9 "
True decli.	2° 58′ 54·4″ = 0·21f1 tims, the answer.

The old system required seven multiplications, one division, four additions, and employed in the calculation about 215 figures, while the *tonal system* required only one multiplication, and employed only 39 figures for the same object, namely, to find the correction.

The old system required a great deal more knowledge of how to manage the many different operations and figures, and in consequence subject to more errors, while the *tonal* system is simple, clear, and natural to the mind. In working the time and lunar observations, the difference will be still more, on account of angles being expressed both in time and degrees.

In the London *Athenæum* for May, 1862, will be found a very severe notice against the Tonal System. The editor, like others who have made remarks on the same, confines himself to mere triflings and some temporary importance, which have no bearing whatever on the principal utility of the system, and does not even make allowance for its being new to him, but plunges into most fickle expressions. The *Athenæum* editor says: "We have ten thousand million objections to the Tonal System." And "We cannot claim the praise of candid and impartial critics; we will see candor and partiality sanbong tone-metre about 24,852 miles beyond Jericho before we will give them a chance of robbing us of our reckoning." Three barley corns is one inch; $2\frac{1}{2}$ inches is one nail (cloth measure); $4\frac{8}{16}$ nails is one foot; $5\frac{1}{2}$ yards is one rod; 22 yards to the surveying chain of 100 links $7\frac{92}{100}$ inches each; &c., &c., up to different kinds of miles about a peck of barley long each; what a beautiful system of metrology England is in danger of being robbed of. The English themselves do not know where the inch came from (save three corns of barley;) they have been looking for its origin down Egypt, and found a place on the Pyramids where the inch fitted. See *Athenæum* June, 1861, and the *Journal Franklin Institute*, Nov., 1861.

There must have been a great many *Athenæum* editors to resist the robbers of the Roman notation which was kept up in public accounts in England almost to the present day, and lately abolished at the expense of burning the Houses of Parliament; if our present barbarous decimal arithmetic and metrology could be abolished and the Tonal System introduced at the same expense, I would propose to burn down that structure immediatly, for the Houses of Parliament are not worth a farthing compared with a natural system of counting. The *Athenæum* editor says that it is "poor argument to grumble about long decimal tails," and that, "The decimal system avoids long decimal tails—if fractions be meant—in twice as many cases as the Tonal System." It will not be more out of reason to say that a sheep's tail is twice as long as an ox's tail, which the editor may succeed to plug into such readers of the *Athenæum* who have never seen a sheep and an ox. As regards decimal tails we have only to refer to a table of logarithms, where we find no end to them. Oliver Byrne has calculated those decimal tails for the single figures up to fifty places, and found no end; while the Tonal logarithms finishes it off correctly at the first and second places. The same with figures in daily use in the shop and the market, the deci-

mal tails are snubbed off to an approximate value, where the Tonal System gives a clear and correct result with the fewest possible figures. As example I have only to refer to my ordinary practice of calculation, for instance, the tables on page 321, eighth edition Nystrom's Pocket Book, which is calculated by the parabolic formula.

$$x = \frac{y^n b}{l^n}.$$

Let us assume values on the letters to $y = \frac{3}{8}$ or 0·375, $b = 1$, $l = 1$, and the exponent $n = \frac{5}{8}$ or 0·625. Required the value of x in the decimal and tonal systems.

Decimal.

Log. 0·375 = 0·5740313 — 1
multiply by n = 0·625

28701565
11480626
34441878

0·3587695625 — 1
— 0·625

Log. 0·5417 = 0·7337695625 — 1
x = 0·5417, the answer.

Tonal.

Log. 0·6 = ·096 — 1
mult. n = 0·9

0·67℘ — 1
— 0·9

Log. 0·89ℰ = 0·℘7℘ — 1
x = 0.89ℰ, the answer.

The long decimal tails consist of 64 figures, while the tonal system employs only 14 figures for the same calculation. The three tonal places are more correct than the four decimals. This is what the *Athenæum* editor calls "poor argument." Poor editor, I do not suppose decimal tails trouble him much.

Lastly, the editor remarks, "Nevertheless, seeing that there cannot be an age of speculation, without cases of extreme indiscretion, we welcome this book as a proof of active mind," showing how far an editor can go when he does not know where he is going. If we could by some means or another pump into the editor of the *Athenæum* only a few advantages of the tonal system, he would surely be so delighted in joy that he would go to the other extreme and cry out, "*matuschka, matuschka*, what an indiscretion that decimal system is." Unfortunately for the editor, he is no doubt sincere in his remarks, sorry though for mankind, to know that such conception can exist in what we might call a centre of civilization.

Let us now apply the tonal system to printing, and we may succeed in bringing it under the *Athenæum* editor's conception. We find that the *Athenæum* is printed from a form of 16 pages, which is 10 tonal, and the whole sheet is 32 pages or 20 tonal. Printing forms are generally made up into 8, 16, 32, &c., pages, and in exceptional cases, for what is called a *medium and a half* sheet, the form is divided into 12, 24, and 48 pages, but we never find a printing form divided into ten pages, and if the *Athenæum* Editor tries to fold a sheet of paper into ten

pages, it will puzzle him more than the tonal system. The critic was probably written by the Professor who generally writes on mathematical work in the *Athenæum*, the author of most parts of the observation on decimal coinage, a very bigoted Professor when on opinion.

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ERRATA.

In the article on the "Tonal System," in the November Number of the Journal, reference is made to the tonal metre, fig. 1, drawn on the rule fig. 3, Plate I.: *fig. 1 and the scale* were left out by the lithogrpher, and the proof sheet did not come under my notice. This figure can be seen in the work on the Tonal System, published by J. B. Lippincott & Co., Philadelphia, which contains a more full description and discussion on the new system. N.

A Dictionary of Mechanical Fallacies.

To the Editor of the Journal of the Franklin Institute.

The suggestion of A Dictionary of Mechanical Fallacies, including superseded devices, in a late number must, I think, commend itself not only to inventors and the Patent-Office, but to every mind interested in the progress of the Arts. But who is to prepare it? It would require the lifetime of an individual. It should, I submit, be the work of, or got up under the auspices of a society that can command a wide correspondence at home and abroad. It would gratify many to learn that the Franklin Institute had taken the subject into consideration. It may be too much to expect a Journal should be devoted to the collection of material, but a portion of one or more established ones might be given up to it. A couple of pages thus occupied would detract nothing from the interest of any monthly mechanical serial. There is probably not one whose pages have not indicated the want of such a work.

Among the premiums awarded last year by the justly celebrated "Société d'Encouragement" of France, is one for a process of tinning leaden pipes, in use here over twenty years ago, and pronounced in 1842, by the United States Court for this district, an infringement of a patent of 1835.

The United States Government can never make a wiser or more profitable appropriation than one to forward such a work. It would reduce by two-thirds the expense and labor of our Patent-Office, and in proportion those of any foreign ones.

There are few thoughts purely new; few of which the germs have not been previously developed. The idea of your correspondent, E, does not appear to be quite original with him. Sir Walter Raleigh, at one time endeavored to reduce to practice a suggestion of Montaigne, by establishing an "Office of Address," intended to serve the purposes now effected by literary and philosophical societies and journals.

The description of the scheme, given by Sir William Petty, affords a striking picture of the difficulties and obstacles which lay in the way of men of study and inquiry between two and three centuries ago.

"It seems [says he] to have been a plan by which the wants and desires of all learned men might be made known to each other, where *they might know what is already done* in the business of learning, *what is at present doing*, and *what is intended to be done;* to the end that, by such a general communication of designs and mutual assistance, the wits and endeavours of the world may no longer be as so many scattered coals, which, having no union, are soon quenched, whereas, being laid together they would have yielded a comfortable light and heat. For the present condition of men is like a field where a battle having been lately fought, we see many legs, arms, and organs of sense lying here and there, which for want of conjunction, and a soul to quicken and enliven them, are fit for nothing but to feed the ravens and infect the air: *so we see many wits and ingenuities* dispersed up and down the world, whereof some are *now laboring to do what is already done*, and *puzzling themselves to re-invent what is already invented:* others we see quite stuck fast in difficulties for default of a few directions which some other men might be met withal, [who] both would and could most easily give. Again, one man requires a small sum of money to carry on some design that requires it, and there is perhaps another who has twice as much ready to bestow upon the same design; but these two having no means to hear the one of the other, the good work intended and desired by both parties does utterly perish and come to nothing." See *Cyclopædia of English Literature.*

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On a new kind of Miniature, possessing apparent Solidity by means of a Combination of Prisms. By Mr. H. Swan.

From the London Athenæum, Sept., 1863.

By this invention is obtained a miniature representation of the human form, or other objects possessing the appearance of perfect solidity, the image being apparently imbedded in the thickness of a small inclosed block of glass or crystal, thereby defining form and expression with a degree of accuracy unattainable in a flat portrait. This is effected by a new application of the principles of binocular vision employed in the ordinary stereoscope. A pair of transparent pictures (taken at an angle suitable for the effect intended) are produced by the ordinary photographic means. To effect the combination of these, the block of glass or quadrangular prism, in the interior of which the solid image is to appear, is composed of two rectangular prisms ground to an angle of about 39° or 40°. These are placed together so as to form one solid quadrangular prism, divided lengthwise by a thin film of air. If one of the pictures be now placed at the back of this combination, and the other picture at the side, on attempting to look through the combination the two images will be superposed on each other (forming one solid image, apparently imbedded in the crystal), all the rays which fall on one side of a line perpendicular to the surface of the prism next to the eye suffering total reflection at the inner oblique surface of that prism, while nearly all those rays which fall on the

other side of this line will be transmitted, unaltered in direction, through the body of the combination. Thus one of the eyes only perceives the object at the back of the prisms, while to the other eye the picture at the side is alone visible, and that lying apparently at the back also, producing the perfect appearance of solidity. It is evident that, to produce these results, care must be taken, not only that the pictures are not misplaced so as to produce the pseudo-scopic effect, but also that the picture which suffers reflection shall be reverted to compensate for the reversion occasioned in reflection.

Proceedings British Association.

International Exhibition, 1862.—*Jurors' Report.*

From the Lond. Civ. Eng. and Arch. Journal, Dec., 1862.

Class VIII.—Machinery in General. *Subdivision III. Pneumatic Machines.*

(Continued from p. 325.)

Section I.—*Air Pumps.*—These pumps are principally represented by exhausting machines for creating a vacuum for the evaporation of syrups in the manufacture of sugar. They are constructed on a nearly uniform model. Each has a vertical steam cylinder with beam, connecting rod, and fly wheel; the pumps, two or four in number, and made of gun metal, are placed on either side of the beam. The construction of this kind of machine has been scarcely modified for many years.

We place in this class the exhausters constructed by Messrs. Gargan and Co. (France, 1031), for the drawing of coal gas from retorts. These machines are represented by excellent drawings by M. Fouche. It is known that in large gas works it is usual for the prevention of waste, to pump the gas from the retorts, in order that the pressure therein may not be raised above that of the atmosphere; whilst it is delivered into the gasometer with the necessary pressure. Blowing fans have also been employed with the same object. Messrs. Gargan have constructed exhausting machines with three parallel double action cylinders, driven by a steam engine. The employment of these three pumps, which draw from a small regulating gasometer, is sufficient to maintain a very regular current of gas. These machines which offer a great economy of motive power over blowing fans, have been adopted by the Gas Company of Paris.

An ingenious instrument of Mr. J. J. Silbermann (France, 1162) was remarked. It is an air pump for physical and chemical researches. It is furnished with a stop-cock, pierced with several openings arranged in such a manner that the pump, which is in communication with three receivers, can pump the gas either in or out of each of the three receivers and into the other two at the will of the operator, by simply turning a stop-cock.

Section II.—*Blowing-fans.*—Among the blowing-fans exhibited may be remarked those of Mr. G. Lloyd (United Kingdom, 1913), and Mr. T. Lemielle (France, 1135). The former was in the exhibition

of 1851; both in Paris in 1855. The first is composed of blades, the width of which decreases from the centre to the circumference. These blades are contained within two cheeks, forming one body with them, and insuring the complete carrying away of the enclosed air. The absence of lateral leakage accounts no doubt for the comparative noiselessness of the action of the machine.

The blowing-fan of Lemielle, the action of which produces air chambers of various capacity, acts rather like a piston machine; it continues to furnish excellent results in the ventilation of mines, and it is employed as an air-blast in many large works.

The North Moor Foundry Company (United Kingdom, 1948), has exhibited a blowing-fan patented by Messrs. Schiele and William, consisting of a fan having its wings curved and of diminishing width, mounted on the same shaft with a steam turbine which drives it. This fan is particularly applicable to the ventilation of steam and sailing vessels.

The Vienna Imperial and Royal Commission for the Ventilation of Military Hospitals (Austria, 630), exhibits a ventilating fan of Dr. Heger. This instrument consists of a wheel, having the same axis as the tube which encloses it, and having blades inclined to this axis, it will be evident that the rotary movement of the blades sets in motion the air within the tube. The variable sections of the tube and of the openings for the passage of the air are arranged in a manner to diminish as much as possible the loss of motive power.

From the reports furnished, this machine appears to have attained a useful effect of 25 per cent. of the power employed, which is considerable for a ventilator.

Section III.—*Blast Engines for Furnaces, &c.*—The blast engines exhibited are very few. The vertical beam engine continues to be preferred in England. A blast engine of very fine workmanship is exhibited by the Lilleshall Company (United Kingdom, 1910).

A double horizontal engine on the system of W. Fossey, is exhibited by M. L. Pérard (Belgium, 273). The admission and expulsion of the air take place through circular sides placed at the bottom of the blowing cylinders, which are pierced with sixteen openings radiating from the centre; the slides have similar openings. In turning round their centre the slides open and close simultaneously all the openings in the bottom of the cylinders; thus is obtained a large area for the admission of air with a slow movement of the valve, which only makes one turn for sixteen made by the machine. During the period of the delivery of air the pressure on the slides is in a great measure compensated by the pressure of the air circulating in a false bottom, which prevents the separation which would be produced in spite of the guides between the slides and the bottom of the cylinders. At a speed of seventy turns per minute this machine can deliver 150 cubic metres of air, at a pressure of eight or ten inches of mercury. Like the blast engine of Messrs. Laurens and Thomas, this machine is free from the shocks of the valves, notwithstanding the great speed of the pistons, but it presents over its predecessor these advantages, viz: that the

speed of the slides is low, and that the pressure on the different parts is balanced, and from this reason they are not so likely to get out of order.

Mr. Holmgren (Sweden, 269) has exhibited a model of a blowing machine of three single-acting vertical blowing cylinders; the driving shaft is placed below, and the connecting rod is composed of four diverging pieces of wood directly attached to the piston. The different positions of the piston are not parallel with each other; if it were replaced by a sphere of the same diameter as the cylinder it would have an action theoretically as perfect as that of a cylindrical piston. To profit by this property there has been provided for the piston a spherical fitting, and the connecting rod lengthened as much as possible to diminish the extent of the oscillations of the piston.

Mons. J. Schaller (Austria, 561) exhibits forge bellows, and a portable forge with double-acting bellows of a cylindrical form, and enclosed in a square case of sheet iron, having on the upper part the fireplace and a small hood.

Section IV.—*Miscellaneous.*—Under this head are arranged a certain number of machines belonging to Class VIII., but which it is difficult to distribute in the different sections of the class as defined by the Jury Directory. In the first place is the apparatus of Dr. Normandy (United Kingdom, 1946) for the production of fresh water from sea water. The water is distilled by the steam from the boilers of the steamship, or from a special boiler in sailing ships.

The apparatus is disposed in such a way as to retain along with the steam from the evaporated water all the air previously dissolved in this water and in that which is employed in condensation, which in the upper part of the condenser nearly reaches the boiling point. This total quantity of air exceeds that which fresh water can hold in solution, so that the condensation produces water perfectly aërated. The empyreumatic taste occasioned by the distillation has still to be got rid of, and this it appears is successfully accomplished by filtration through wood charcoal. The whole apparatus is simply and practically disposed; the evaporation is entirely self-acting, requiring only the regulation of some stop-cocks.

The machines for the manufacture of aërated waters are very numerous, and are generally well constructed. It could hardly be otherwise with the manufacturing machinery required by an industry which becomes daily more extended.

M. Heckmann (Prussia, 1303) has exhibited an evaporating pan of large dimensions, for the boiling of sugar in vacuo, 3 metres diameter, and 3·60 metres high, and of very good workmanship.

M. F. Legal (France, 1157) has sent the model of a similar sugar vacuum pan, with some peculiar modifications to avoid the carrying over of sugar with the steam.

Subdivision IV.—Hydraulic Machines, Cranes, &c.

Section I.—*Hydraulic Machines, Pumps, and Fire Engines.**—The

* The report on the fire engines was drawn up by the Special Jury on that subject.

different systems of pumps are represented in great number. Among the chain pumps may be remarked that of Mr. J. U. Bastier (United Kingdom, 1792), formed by a series of circular pistons in caoutchouc, moving in a tube of iron enamelled on the inside. To avoid friction the pistons have a diameter somewhat smaller than that of the tube, which itself is slightly narrowed at the lower part, sufficient to allow the pistons to pass with slight friction, thus preventing all loss of water. This apparatus is easily fixed; but we think nevertheless, that the other pumps would be preferred for great quantities of water, or for great depths.

Murray's chain pump, exhibited by Mr. Middleton (United Kingdom, 1930), formed of plates of wood firmly connected together with iron chains, and moving in a rectangular case or trunk, is easily set up for temporary drainage purposes.

The force and lift pumps are in great variety; a large number of constructors have sought to give to the waterways and valves dimensions which render as small as possible the loss of power by friction. They have also sought to give a continuous movement to the ascending column of water, independently of the action of the reservoir of air. This result is obtained in the pump of Messrs. Carrett, Marshall, and Co. (United Kingdom, 1813). The solid piston is worked by a rod of half the section of the piston itself; during the up-stroke the upper surface forces a volume of water into the ascending column, and the lower surface draws in twice that volume. In the down stroke these two volumes are sent into the receptacle communicating with the upper face of the piston. One of the volnmes here fills the space which would otherwise be left empty; by the descent of the piston the other volume is sent into the rising tube. These pumps, which are of small size, are only exhibited as donkey pumps, for the continuous feeding of steam boilers with water.

The uniform movement of the water is obtained in a still more simple manner in the pump of Messrs. Farcot and Sons (France, 1152), in which two equal pistons with valves affording very large waterways, work parallel to each other in two pump cylinders. During the successive strokes the first piston draws in water by its upper surface, and delivers it to the ascending column by causing it to traverse the second piston. In its ascending course, the second piston raises in its turn the column of water by its upper face, whilst the lower face sucks the water, causing it to traverse the upper piston. This pump has yielded all the good results promised by its ingenious construction, and it is adopted in the water supply of Paris.

M. Letestu (France, 1167) exhibits pumps which are already very well known, as well as a double pump of large dimensions for drainage purposes. It is chiefly in operations where the waters are charged with mud or gravel that the pumps of M. Letestu have been found most useful.

The pump of Messrs. Knowelden and Co. (United Kingdom, 1901) has the general disposition of a fine engine pump, but between the extremity of the piston and the valves is a diaphragm; the free space

between the piston and this membrane is filled with water covered with a layer of oil, so that the greasing of the piston is always perfect, and no sort of liquid nor foreign body can interrupt the action of the piston. The four valves, inlet and outlet, are arranged on the same bed plate, and can be easily visited and repaired. Their grouping presents this advantage, that by turning the bed plate this pump acts in the opposite sense, and can thus easily cleanse the ascending tube from any foreign bodies which have happened to get in, as they are very apt to do.

M. Perreaux (France, 1142) exhibits valvular pistons in caoutchouc. The piston is in one piece, and hollow below, and terminated in the upper part by two thin lips, generally closed, and so much the more effectually as the pressure above is greater, but which open to leave a passage for the water from below as soon as the pressure on this side predominates. With this piston, and a similar piece forming a bottom valve, a pump is obtained of a very simple construction. It is necessary to remark, however, that the repairs of the pistons in the generality of cases cannot be easy, and that the resistance of the material at the opening, and the small dimensions of the orifices, require an excess of motive power which would become of importance in pumps of any but of small dimensions.

The centrifugal pumps are chiefly represented by the systems of Appold and Gwynne. The first, constructed by Messrs. Easton, Amos, and Sons, obtained a very remarkable success in the first universal Exhibition of 1851. The second, very inferior at that time as regards the successful employment of motive power, has been so well modified, that in the absence of comparative trials it would be difficult to decide to which of these two machines the preference should be given, for they offer no essential difference except in the position of the axis of the wheel, which is vertical in the first and horizontal in the second. We believe that this system of pumps will receive numerous applications by the ease with which it can be set up, and its working without shock; by the employment of a steam engine at a high rate of speed, which would be easy of transport and readily fixed. It is well fitted for employment in large temporary drainage works.

We would mention also, for simplicity of arrangement of the different parts, the drainage pump of Mr. Godwin, (United Kingdom, 1862), and the double-acting pump of Mr. Hansbrow (United States, 40), and the double-acting pumps of M. Hubert (France, 1200), which furnish the French fountains in the grounds of the Horticultural Society.

Steam Pumps.—Messrs. Harvey and Co. (United Kingdom, 1880), employed in more than half of the water works in London, have exhibited a model of one of their single-acting steam pumps, imitated from the drainage pumps of the Cornish mines. They are now adopted in nearly all large towns. The comparative experiment which will shortly be made at Paris between this system and that of Messrs. Farcot and Son (France, 1152), will therefore be highly interesting. It is useful to remember that in the Cornish engines, even in those used

for the drainage of mines, where the mass in movement is more considerable, the action of the steam valve has never been so perfect as desirable. The diameter of the piston has always been too large to allow of the admission of steam at the pressure in the boiler (30 to 45 lbs.) without causing a detrimental velocity; there arises a throttling effect which absorbs a great part of the available work.

A great number of steam feed pumps are to be found at the Exhibition, all with steam and water pistons on the same piston rod, sometimes vertical but more often horizontal.

Two pumps may be seen from the United States; Mr. H. Steel (39), and Mr. Worthington (28). They are without fly wheels; one of them has only one steam cylinder and one pump; the slide valve is brought into action instantaneously at each stroke of the piston by means of a small supplementary steam piston very ingeniously disposed. The other pump is composed of two cylinders of each kind; the steam slide valve is guided in each machine by the piston rod of the other; by this means the movements are simultaneous in opposite directions with perfect regularity.

To mention Giffard's injectors, exhibited by Messrs. Sharp, Stewart and Co. (United Kingdom, 1209), Flaud (France, 1164), is to record their success. They are found at the Exhibition universally amongst the principal industrial nations, thus showing how this invention has been appreciated.

Professor Colladon (Switzerland, 106) is the inventor of a water-wheel to be set in motion by large streams of water, and constructed on the most scientific principles. It is at present used for the raising of water; between two exterior cylindrical surfaces exists a spiral partition in which the water stands at the level of the axis, and can be raised to a height commensurate with the number of the spirals.

Messrs. Wentworth and Jarvis (United States, 54) exhibit a windmill for the raising of water; self-regulating when the force of the wind increases; the guide sails close in, and increase the obliquity of the angle formed by the motor sails with the direction of the wind.

There has also been placed in Class VIII. a well arranged machine for washing and bleaching of tissues, exhibited by Messrs. Sulzer Brothers (Switzerland, 112), and a machine for washing linen by Mr. Parker (United States, 89).

Water Rams.—The different hydraulic rams exhibit no new arrangement, with the exception of that of Messrs. Bollée and Son (France, 1165). By the adoption of a clack valve analogous to double seated valves, he diminishes considerably the intensity of the shock; the pump feeding the air reservoir set in movement by the play of the ram, but always situated above the level of the highest waters, works even whilst the ram is under water, which allows it to be placed in such a manner as to profit by all the height of the fall. Finally, the valve is counterpoised at will by a regulator, by means of which the velocity of the machine is governed. There is here a manifest progress which should render the use of this machine more frequent.

Hydraulic Presses.—Among the hydraulic presses exhibited, there are some in which it has been sought to perfect the movement of the pumps; we may mention that of Messrs. Peel, Williams, and Peel (United Kingdom, 1954), in which the two pumps of different diameters work together. Both work in the usual way up to a pressure determined beforehand; when the effect of the large pump ceases the small pump works alone to the point fixed for the maximum pressure to be obtained, and when its play ceases to have any effect. This modification of the working of pumps is obtained by the very ingenious arrangement of two safety valves acting on the same lever; so that when the pressure reaches the first fixed limit, a valve is raised and gives to the lever a slight movement which causes the water to be driven into the cistern instead of the press; at the second limit another supply valve, raising the former fulcrum of the lever, annihilates in its turn in the same way the action of the small pump. As soon as the pressure descends below the second or first limit, the small pump, and then the large one, recommence their effective work.

Mr. F. O. Ward (United Kingdom, 2015) has sought simplification of another kind. On a hollow bed, serving also as a cistern, he groups a horizontal steam engine and pumps, thus compressing two machines into the space of one. The pumps are peculiarly constructed to avoid accumulation of air. They are also of thrice the usual length, and coupled in pairs by a novel arrangement, allowing all four to be driven by two connecting rods—a considerable economy. That their threefold length may not involve diminished directness of thrust, the connecting rods are proportionately lengthened. Thus twelve pumps with their twelve sets of valves are replaced by four, and twelve connecting rods, with their costly fittings, by two. This cheapened construction implies less cost of maintenance, fewer working parts and reciprocating motions, fewer valve beats, and less "back slip." The power is transmitted by pinion and spur wheel, geared to afford suitable leverage and suitable relative velocity of the steam and water in motion. These are all points of advantage, but it would seem desirable to isolate the steam cylinder from the cistern, in order to avoid refrigeration.

M. Lecointe (France, 1166) has obtained a simplification still greater: his apparatus of pumps and cisterns can supply twelve presses. It consists of two force pumps, the contents of which are led into a reservoir of variable capacity by the play of a plunger moving vertically, weighted to 1200 or 1400 lbs. to the square inch. It is this reservoir which distributes the water to the presses at this constant pressure. If the pumps furnish more water than is used, the regulating piston, arriving near the extremity of the stroke, raises a balance weight, the action of which immediately cuts off the action of the pumps. The power returns as soon as the piston of the reservoir is lowered; but this return of power is combined in such a way that it takes place only at the commencement of the stroke of the piston, so as to drive the water with slow velocity at first, essential to the preservation of the machine. The mechanical regulator is ingenious; but it is advisable to avoid the noisy shock of the connecting rod

against the clutching lever, which continues as long as only one of the pumps is in action. With the exception of this objection to a matter of detail, the machine of M. Lecointe presents a very important progress in the production of hydraulic presses, and the success which this machine has obtained in a great number of works is perfectly well deserved.

Water Metres, &c.—Water metres are of many different constructions. That of Mr. Siemens (United Kingdom, 1987), which was to be seen in the Exhibition of 1851, consists of a small turbine traversed by the water to be measured. It remains to be decided by well authenticated trials whether this instrument registers accurately under the different pressures with which water may have to traverse it.

The other systems of metres consist of filling with water a constant capacity, and registering the number of the operations. That of Mr. Jopling, exhibited by Messrs. T. Lambert and Sons (United Kingdom, 1903), is of very simple construction. It is composed of two equal parallel cylinders, of which the pistons work together in the same direction, the piston rod of each piston regulating at the extremity of the stroke the admission of the water into the neighboring cistern. All the water must pass through one or the other of these two cylinders; and the number of oscillations registered measures the quantity of water which has passed. The cylinders are enclosed in a case of cast iron, so that the pressure is the same at the exterior as the interior of the cylinders, and its influence on the play of the machine is nearly annihilated.

The Manchester Water Metre Company (United Kingdom, 1923) exhibit several water metres. One of them is provided with only one cylinder, in which the introduction of the water is regulated by a system of two pistons, which are alternately driven in different directions by a slide, the piston of which is changed by the piston rod of the large piston at each end of its stroke. Among the other water metres of the Company may be seen one (Frost's patent) without packing, which will work with warm water, for the filling of steam boilers. It is composed of two pumps, formed each of a rectangular box, moving horizontally in the right angle formed by two fixed planes. A partition, fixed perpendicularly in the intersection of the two planes, and filling the section of the box, performs the office of a fixed piston, and separates the two cavities of the box, which fill alternately, as they are extended. The box slides in grooves adjusted on the fixed planes, each governing the slide valve of the other. It would be very desirable that regular experiments should be made with these instruments, which would be very rapidly adopted by the public, could they confide in the register of the machines.

M. Sacré (Belgium, 277) has exhibited a hydrometer for distilleries. The liquid is measured as it leaves the still, at the same time that a small quantity of liquid, variable at pleasure, is preserved at each measuring, and conducted into a special receptable, which allows of recording readily the mean density of the liquid distilled.

SECTION II.—*Cranes.*—The principal kinds of machines for lifting exhibited, are either cranes or jacks.

With the cranes are ranged those called Derrick cranes, presenting generally an extended basis, and consequently great stability. Cranes properly so called are either fixed or movable, worked by hand, steam, or water. We remark in the two first classes the system of M. Neustadt, exhibited by J. F. Cail and Co. (France, 1144), and C. Fauconnier (France, 1161), which consists in applying to cranes the Galle chain. This chain, formed of plates of wrought iron united by pins, has no forged joints, and presents a very great solidity. It adapts itself to the teeth of a pinion, and the free extremity of the chain is received into a box or directed into a sheath. This system presents over the others the advantage of doing away with the drum and one of the cog wheels, seeing that the diameter of the pinion is about one-third of that of the drum; of avoiding the oblique winding of the chain, and consequently of notably simplifying the construction of cranes. An experience of seven years has confirmed the use of cranes with the Galle chain. Nearly 500 of them have been constructed, and are used in large establishments. Amongst the most important are those of the Imperial Marine of France.

A crane moved by hydraulic pressure forms part of the exhibition of Sir William Armstrong & Company (United Kingdom, 1785), and which also appeared in the Exhibition of 1851. The drum is totally suppressed: the chain of the crane when it reaches the head of the vertical standard is passed over pulleys; one of the pulleys is fixed, and the other is set in movement by a piston of a hydraulic press. The rotation of the crane is also effected by the pressure of water. This crane is suitable for a locality where water is distributed at a high pressure. It can be fed from a high-pressure hydraulic reservoir, the reservoir itself, fed by force pumps driven by steam, furnishing an advantageous means of replacing the continuous work of the machine by the intermittent work of the crane. The Armstrong system comprehends also a capstan moved by water under high pressure. Three pumps are thus put in motion, and work together on a horizontal shaft carrying a conical pinion which works against a wheel fixed at the base of the capstan.

Messrs. Ransomes and Sims (United Kingdom, 1961) have exhibited a portable steam-engine which can act as a steam capstan. A winding drum is placed beneath the boiler; it is driven by a conical-toothed wheel, put in motion by the steam-engine situated over the boiler. The whole of this arrangement is ingenious; but it may readily be understood that this machine cannot exercise very great power. The machine exhibited could only raise 25 cwt. The most useful application of it would be in the raising of building materials.

The hydraulic lifting jacks already seen at the Exhibition of 1851 have become more numerous. In those of Messrs. Adamson and Co. (United Kingdom, 1780), the oscillations of the lever in raising are lessened by an angle block which butts against the head of the jack. It is only by moving the lever laterally on its axis that the stopping

of the operation is prevented, and that the water from the bottom of the press is allowed to pass into the head of the jack, causing at the same time the lowering of the object lifted. With the machine of Messrs. Tangey, Brothers, and Price (United Kingdom, 2002), the lowering is obtained by a special screw. These instruments are simple, and offer great advantages over those with rack wheels.

We must also draw attention to the crab of Mr. Winand (Belgium, 28), set in motion by an endless screw which can guide the gearing, but cannot be moved by it. The lowering of the weights can only be obtained by turning a handle in the opposite direction, or by unwinding the screw when a rapid movement is desired.

(To be Continued.)

Atmospheric Changes.

From the London Athenæum, September, 1863.

Prof. Tyndall sends us for publication some curious Alpine experiences of Mr. Robert Spencer Watson and his party in the region of the Jungfrau. The suddenness of the atmospheric changes will recall the similar observations of Mr. Whymper on the Matterhorn.

Mr. Watson says:—"On the 10th of July I visited the Col de la Jungfrau from the Æggisch-horn, in company with my wife and Messrs. John Sowerby and W. G. Adams, of Marlborough College. We had with us as guides J. M. Claret, of Chamouni, and a young man from the hotel. The early morning was bright, and gave promise of a fine day, but, as we approached the Col, clouds settled down upon it, and on reaching it we encountered so severe a storm of wind, snow, and hail, that we were unable to stay more than a few minutes. As we descended, the snow continued to fall so densely that we lost our way, and for some time we were wandering up the Lötsch Sattel. We had hardly discovered our mistake when a loud peal of thunder was heard, and shortly after I observed that a strange singing sound like that of a kettle was issuing from my alpenstock. We halted, and finding that all the axes and stocks emitted the same sound, stuck them into the snow. The guide from the hotel now pulled off his cap, shouting that his head burned, and his hair was seen to have a similar appearance to that which it would have presented had he been on an insulated stool under a powerful electrical machine. We all of us experienced the sensation of pricking or burning in some part of the body, more especially in the head and face, my hair also standing on end in an uncomfortable but very amusing manner. The snow gave out a hissing as though a heavy shower of hail were falling; the veil on the wide-awake of one of the party stood upright in the air, and on waving our hands the singing sound issued loudly from the fingers. Whenever a peal of thunder was heard the phenomena ceased, to be resumed before the echoes had died away. At these times we felt shocks, more or less violent, in those portions of the body which were most affected. By one of these my right arm was paralyzed so completely that I could neither use nor raise it for several minutes, nor indeed until it had been severely rubbed by Claret, and I suffered much pain in it at

the shoulder-joint for several hours. At half past twelve the clouds began to pass away, and the phenomena finally ceased, having lasted twenty-five minutes. We saw no lightning, and were puzzled at first as to whether we should be afraid or amused. The young guide was very much alarmed, but Claret, who is devoid of fear, and who had twice before heard the singing (though without any of the other symptoms), laughed so heartily that we joined him. No evil effects were felt afterwards beyond the inconvenience arising from the burning of our faces, which, though we had no sun, were almost livid in hue when we arrived at the Æggisch-horn."

Preservation of Iron Plated and other Ships.

From the Journal of the Society of Arts, No. 559.

A process has been invented by Monsieur Jean Pierre Jouvin, Chief Medical Officer of the French Navy, and Professor of Chemistry to the Naval School of Medicine at Rochefort, "For Preserving Iron Plated and other Vessels and Metallic Articles from Oxidation, and Preventing Ships' Bottoms from Fouling." The French Government are now making trial of the process by covering two iron-clad vessels with the preparation.

The invention has been patented in England, and consists (as described by the inventor) in lining the inner surface of ships' sides and bottoms, perfectly scoured, with sheets or lamina of zinc applied directly against the sheet-iron, and there held fast between the latter and the frames. But as iron ships now afloat present some difficulty to the application of such zinc sheathing in the interior of their holds, the internal sides of the hold are first carefully scoured, and afterwards a double coat of a paint made of powdered metallic zinc applied thereon, which is spread all over from the keel up to a little above the water line. As zinc paint, on account of the fatty matter it contains, does not act as an electric protector with the same efficiency as zinc when employed in the form of sheets, it is necessary to increase the area of the protecting surface.

For iron ships on the stocks, as soon as the keel, the stem, the stern-post, and frame are set up, they receive a thick layer of the aforesaid metallic zinc paint. The boarding of the keel and sides is afterwards proceeded with as usual, care being taken to apply underneath the timber employed a coat of the same paint, or in lieu thereof sheets of greasy felt thickly sprinkled with powdered metallic zinc. The zinc sheets are then applied without difficulty, and become bound with the sheets of iron of the streaks from the keel up to the water-line, and from the stem up to the stern-post, so as to form part with them. The sheets of zinc are held between the sheets of iron which form the stem and the keel, and, assuming the shape of the sheets to be protected form continuous bands extending right and left and from the bottom upwards, so as to meet again and join each other, between the sheet iron forming the stern-post, and to have their ends in the vicinity of the helm and the water-line. As the riveting takes place

at a temperatere higher than that of the melting of zinc, and approaching that at which this metal evaporates, part of the sheets around the heads of the rivets would be destroyed; to avoid this defect, the sheets of zinc must be of a sufficient breadth and length to cover the sheet iron to within one-third of an inch of the rivets, without reaching them. The phenomena of dilatation could, therefore, freely take place on the preserving plates, the co efficient of expansibility of these plates being nearly double that of iron.

For those parts of the zinc plates held between the frames and the sheet iron, in order to insure a complete riveting of iron on iron, it is necessary to begin by cutting washers or disks, by the ordinary means, in these bands opposite each hole of the rivets. The diameter of these washers must be double that of the rivets, and they are finally replaced by rings of sheet-iron, the diameter and thickness being equal to that of the bands of zinc. The covering bands and the heads of the rivets must receive a thick coat of metallic zinc paint. In the electro chemical scale, the protecting metal (zinc) coming immediately after the protected metal (iron), it will be advantageous to have the protecting surface as nearly as possible of the same dimensions as those of the surface to be protected. It is found that the protecting bands of zinc, if properly fixed from the keel up to the water-line, may be only about two-thirds at maximum, and about one-tenth at minimum of the last surface, provided all the spaces between the zinc bands be covered with the metallic zinc paint. The zinc sheets should measure about one-fourteenth of an inch in thickness for the lower part and about one-twenty-eighth of an inch for the sides of the hold. When the ship is built, all the parts of iron composing the hold—such as the ribs, keelsons, clamps, transversal bulkheads, and others not covered by the zinc band, are carefully scoured, brushed, or otherwise cleaned, and then coated with metallic zinc paint.

To protect the exterior part of the hull immersed from the deposit of marine sheets and plants, the inventor proceeds as follows: He states that turbith mineral (SO^3 3HgO) mixed with Prussian blue ($3Fe\,Cy + 2Fe^2\,Cy^3$) produces by its contact with the alkaline chlorides of sea-water, one of the most violent poisons known to mineral chemistry, namely—the cyanide of mercury (Hy Cy) in the shape of chloro-cyanide of mercury and sodium. He therefore first mixes fifty-five parts of turbith mineral with forty-five parts of Prussian blue of the commonest tint, but not adulterated, so as to obtain a green powder perfectly homogeneous, and composes the poisonous paint as follows: Of boiled linseed oil, 250 parts; red lead (or any other agent which may cover or adhere as well or better than red lead), which is here used as a mere vehicle for the poisonous compound, 650 to 660 parts; the hereinbefore described mixture, 90 to 100 parts. These substances must be well ground together in order to effect a uniform and complete distribution of the poisonous compound throughout the mass of the paint. But as iron possesses the property of reducing mercurial and leaden compounds, this preparation must not be applied direct on the bare metal, all the parts of the hull, namely, the sheet iron of the keel,

cut-water, rudder, paddle-wheel frames, and every part of iron to be immersed or wetted, must be previously coated with two layers of the metallic zinc paint, after being scoured as completely as possible. When these layers of metallic zinc paint are quite dry, the poisonous compound or paint is applied thereon. This poisonous compound may prove also very advantageous if applied to wood employed to secure dikes, embankments, and for marine constructions to protect them from injury by teredos. The smallest particle of the chloro-cyanide of mercury and sodium produced by its contact with sea salt, suffices to kill instantaneously animalculæ, plants, and even their germs when brought within its influence.

To apply the invention to iron-plated vessels, there must either be placed between the wood-work of the hull and each iron plate a sheet of zinc, the surface of which is rather smaller than that of the iron plate, or this wood-work must be coated with a thick layer of metallic zinc paint; then each iron plate, previously well scoured, is similarly painted on its inner face, and adapted to the sides of the ship. The ship being finished, the whole of her bottom to be immersed in water is treated in the manner before described, that is to say, first coated with a double layer of metallic zinc paint, and afterwards with the poisonous compound paint. To preserve sheet-iron tanks, marine boilers, steam engines, and other similar articles from oxidation, the inventor either applies on them externally zinc sheets, or coats them with a double layer of the afore-mentioned metallic zinc paint.

To preserve the parts of cables and chains stored in wells, where they are oxidized very rapidly, a band of zinc is fastened by screws on each of the rings or links. The metallic zinc paint may be applied to iron articles in general, wherever red paint is now made use of, and as a substitute for it. For ships bottoms with a copper sheathing, before the sheathing is applied the wood-work is coated over with a thick layer of metallic zinc paint. But in the present case it is more economical to employ powdered cast iron, or, in preference, iron powder, instead of zinc powder, to prepare the metallic protecting paint, as it will protect copper as effectually. Should it be found, however, that the copper sheathing gets foul with barnacles and sea-weeds, it must be coated with the poisonous compound before mentioned.

Oiling Wool by Machinery.

From the Journal of the Society of Arts, No. 559.

In order to render wool more workable than it is in its native state, it is customary to oil it, a process which has the effect of causing the fibres to slip more readily and evenly, and ensure more perfect cording and regular yarn. Hitherto the oil has been distributed by hand from a syringe, watering-can, or similar instrument; and the result has been that the oil has been diffused very irregularly, in some places the wool being saturated and clotted, and in others escaping altogether. This inequality in the oiling of the wool produces similar inequalities in the yarn, and the defects of the process are discernible in the various

stages of manufacture. Mr. Leach of the firm of Messrs. Littles, Leach, & Co., Britannia Mills, Leeds, has put forward a plan for obviating this difficulty. The invention has the advantage of being readily attached to willies, teazers, pluckers, burring, and other machines employed in the manufacture of wool, and is so constructed that it can distribute oil to any given extent, the machine measuring and distributing the liquid with considerable accuracy. As the wool passes along the feed-sheet of the preparing machine, the oil is by means of the apparatus, scattered over it in the form of a spray or mist, so that the wool is thoroughly oiled, a fact which could be detected by feeling the wool; but the oil having been so evenly and accurately distributed, was not perceptible to the eye. The quantity of oil can be varied at pleasure, and, by a simple arrangement, it can be conveyed to the machine in pipes from the cask or cistern, thus saving much labor and preventing waste.

On Boiler Explosions. By Mr. P. Le Neve Foster.

From the London Athenæum, Sept., 1863.

The author stated that, in considering the cause of the extensive mischief done by the bursting of a high-pressure boiler, it is evident that the small quantity of steam contained in the steam-chamber has very little to do with it. The steam may immediately produce the rupture, but as soon as the rupture is made, and some steam escapes, and the pressure on the water is diminished, a portion of the water is immediately converted into steam at a slightly lower temperature and lower pressure, and this, in the same way, is followed by other steam at still lower temperature and pressure, and so on till the temperature is reduced to 212° Fahr. and the pressure to 0. Then there remains in the boiler a portion of water at the boiling point, the other portion having gone off in the shape of steam of continually diminishing pressure. From this it is evident that the destructive energy of the steam, when a certain pressure is shown by the steam-gauge, is proportional to the quantity of water in the boiler. By the assistance of Professor Miller, of Cambridge, Messrs. Ransome, of Ipswich, and George Biddell, Esq., the author has been able to obtain a result which he believes to be worthy of every confidence. He first stated, as the immediate result of Mr. Biddell's experiments, that when there were in the boiler of a small locomotive 22 cubic feet of water, at the pressure of 60lbs. per square inch, and the fire was raked out, and the steam was allowed gently to escape, with perfect security against priming, the quantity of water which passed off before the pressure was reduced to 0 was $2\frac{3}{4}$ cubic feet, or $\frac{1}{8}$ of the whole. In regard to the use made of Professor Miller's theory, Professor Miller had succeeded in obtaining a numerical expression for the pressure of steam at twelve different measures of the volume occupied by water and steam, which expression the author had succeeded in integrating accurately, and had thus obtained an accurate numerical expression for the destructive energy of steam. In regard to the use of General

Didion's experiments, these experiments gave the velocity of the ball, in cannon of different sizes, produced by different charges of powder.

The author found, by trial with the formula $\frac{Wv^2}{2g \times \text{weight of powder}}$, which of these experiments exhibits the greatest energy per kilogramme of powder, and had adopted it in the comparison. The result is as follows:—the destructive energy of one cubic foot, of water, at 60 lbs. pressure per square inch, is equal to the destructive energy of two English pounds of gunpowder in General Didion's cannon experiments; General Didion's experiments were made, as the author understood, with smooth-bored cannon. It cannot be doubted that much energy is lost in the windage; some also from the circumstance that the propelling power ceases at the muzzle of the gun, before all the energy is expended; and some from the coolness of the metal. If we suppose that, from all causes, one-half of the energy is lost, then we have this simple result; the gauge-pressure being 60 lbs. per square inch, 1 cubic foot of water is as destructive as 1 lb. of gunpowder. In one of Mr. Biddell's experiments, the steam-valve was opened rather suddenly, and the steam escaped instantly with a report like that of a very heavy piece of ordnance. This is not to be wondered at; it appears from the comparison above that the effect was the same as that of firing a cannon whose charge is 44 lbs. of powder.

Proceedings British Association.

FRANKLIN INSTITUTE.

Proceedings of the Stated Monthly Meeting, November 19, 1863.

John C. Cresson, President, in the Chair.

Isaac B. Garrigues, Recording Secretary.

The minutes of the last meeting were read and approved.

Letters were read from from l'Académia Real das Sciencias de Lisboa, Portugal, and Thomas Oldham, Esq., Superintendent of the Geological Survey of India, Calcutta, India.

Donations to the Library were received from the Royal Geographical Society, the Royal Astronomical Society, the Chemical Society, the Zoological Society, the Statistical Society, and the Society of Arts, London; l'Ecole des Mines, la Société d'éncouragement pour l'industrié nationale, Paris, and la Sociéte Industrielle de Mulhouse, France; l'Academia Real das Sciencias de Lisboa, Portugal; T. Oldham, Esq., Superintendent of the Geological Survey of India, Calcutta, India; Major L. A. Huguet-Latour, Montreal, Canada; the Department of Agriculture, and F. Emmerick, Esq., Washington, D. C.; the Sanitary Commission, City of New York; F. Carroll Brewster, Esq., Lorin Blodget, Esq., and Capt. Samuel W. Dewey, Philadelphia.

The Periodicals received in exchange for the Journal of the Institute were laid on the table.

The Treasurer's statement of the receipts and payments for the month of October was read.

The Board of Managers and Standing Committees reported their minutes.

Twelve resignations of membership in the Institute were read and accepted.

Candidates for membership in the Institute (25) were proposed, and those proposed at the last meeting (4) were duly elected.

Prof. Fleury gave the following explanation of Dr. P. H. Vander Weyde's new process of Stereotyping.

This invention consists in preparing incombustible papier maché moulds, capable of receiving and permanently holding the impression of forms of type, and in making castings of stereotype plates therefrom. The application of this invention to the purposes of stereotyping, will effect a great saving of labor and material in the publication of books and other printed matter. Up to the present time, publishers who have desired to preserve the forms from which their works were printed for subsequent editions, have been required to have stereotyped plates of said forms, cast in type metal, involving an outlay of capital which must remain unproductive until further editions of such works are called for. For a common size octavo book of four hundred pages, plates weighing about one thousand pounds must be kept on hand, and when worn out, as they will be by the printing of a few thousand copies with them, and a further demand is had for such works, the labor of composition, correcting, moulding, and stereotyping have to be again performed and the consequent expense thereof defrayed.

By the use of Dr. Vander Weyde's invention, the publishers need only keep the paper moulds from which to cast their plates as they may have occasion to use them. They can be preserved for any length of time, and are not thereby exposed to the accidents and injury attendant on storing of metallic plates. Further, every form may be distributed as soon as the mould is made without waiting for the results of the casting, as a second cast may be obtained if the first should not be approved, or a third or a fourth in like manner may be taken. After casting with these moulds, the moulds are not thereby destroyed (as is the case in all other modes of stereotyping and electrotyping), and they may be preserved for other castings to be taken from them. Instead of an easily fusible alloy, the common stereotype metal is used in this process.

The shaving process now in use may be dispensed with, as the thickness of the plates can, by this process, be regulated with accuracy and precision.

The Professor then described the method of preparing the incombustible paper and manner of casting, exhibiting also a pamphlet printed from a plate that had been cast by this new process. Any further information on this subject can be had by addressing the in-

ventor at the Cooper Union, New York, or Mr. Fleury at his office, in the Hall of the Franklin Institute in this city.

Mr. Nystrom remarked that he had seen paper moulds for stereotyping made by Edward Scheutz's Interpolating machine, invented in Stockholm in the year 1837, and exhibited in the French International Exhibition, 1855. The machine calculates, sets up and prints numbers into pasteboard in the form of tables, from which the stereotype plates are cast. Mr. Nystrom said he had in his possession tables of logarithms produced by said machine, and that said machine was bought by the Albany University, N. Y., where it is now in operation; also one in the Somerset House, London, by which tables of mortality, &c., are calculated under the superintendence of Dr. W. Farr.

Prof. Fleury remarked that, there is something new in making the mould incombustible, to which Mr. Nystrom replied, I have no doubt but that there is originality and novelty in Prof. Vander Weyde's scheme, and think him entitled to great credit if he succeeds to bring it into practice, and relieve stereotypers of the clumsy and dirty plaster paris operation, slow and expensive electrotyping; I merely refer to facts in my knowledge. The stereotype metal is not so very hot, you can stick your finger into it.

Prof. Fleury then exhibited samples of a new artificial Fuel and Gas material, the invention of William Gerhardt of this city.

This invention consists in preparing porous bricks, balls, or otherwise shaped fire proof material, which are imbibed and fully saturated with gas tar, coal oil, or any other hydrocarbon of similar nature. These bricks are afterwards dried and used for the purpose of producing illuminating gas, or as fuel. The oil having burnt out, the material is used over again; it leaves no ashes, and preserves its porosity. The use of fuel that is free from sulphur is of the highest importance in the manufacture of steel, iron, glass, &c., and this artificial fuel is therefore well adapted for these purposes as well as for other uses, because the price of manufacture is not so high as the present price of coal. Those who desire further information may address Mr. J. G. Kershaw, Attorney at Law, No. 324 Chestnut street.

The Professor finally read a paper recommending the establishment of a Free Polytechnic University, where engineers, mechanics, manufacturers, and artists could receive gratuitous instruction in the applied sciences of Chemistry, Physic, Mechanics, and Mathematics, and where all important improvements and discoveries that are made in Europe and this country are speedily collected and brought to the knowledge of the respective branches, and all matters relating to the advancement of the Sciences and the Arts are discussed.

Mr. Washington Jones exhibited Mr. H. H. Hall's Improved Piston Packing; the piston being surrounded by sections of metal which simultaneously force outwards in close contact with the interior of the cylinder by cams inside the piston.

A Comparison of some of the Meteorological Phenomena of OCT., 1863, *with those of* OCT., 1862, *and of the same month for* THIRTEEN *years, at Philadelphia, Pa.* Barometer 60 feet above mean tide in the Delaware River. Latitude 39° 57½′ N.; Longitude 75° 10½′ W. from Greenwich. By JAMES A. KIRKPATRICK, A. M.

	Oct. 1863.	Oct. 1862.	Oct. 13 years.
Thermometer—Highest—degree, .	74·0°	86·0°	90·0°
" " date .	2d.	8th.	4th, 1858.
" Warmest day—Mean,	67·33	76·50	78·30
" " " date,	2d.	4th.	6th, 1861.
" Lowest—degree, .	32·00	35·00	28·00
" " date, . .	26th & 27th.	28th.	25th, 1856.
" Coldest day—Mean,	40·00	43·00	35·80
" " " date, .	26th.	27th.	27th, 1859.
" Mean daily oscillation,	16·10	15·31	15·76
" " " range, .	4·93	5·48	5·50
" Means at 7 A. M., .	49·79	52·70	51·27
" " 2 P. M., .	61·89	64·29	63·31
" " 9 P. M., .	54·18	56·98	55·51
" " for the month,	55·29	57·99	56·70
Barometer—Highest—Inches, .	30·245 in.	30·201 in.	30·452 in.
" " date, . .	26th.	24th.	25th, 1861.
" Greatest mean daily press.	30·209	30·118	30·378
" " date, . .	26th.	24th.	25th, 1861.
" Lowest—Inches, .	29·557	29·307	29·012
" " date, . .	2d.	27th.	26th, 1857.
" Least mean daily press.,	29·637	29·492	29·059
" " date, . .	3d.	27th.	26th, 1857.
" Mean daily range, .	0·108	0·151	0·143
" Means at 7 A. M., .	29·920	29·865	29·931
" " 2 P. M., .	29·885	29·825	29·888
" " 9 P. M., .	29·925	29·859	29·912
" " for the month,	29·910	29·850	29·911
Force of Vapor—Greatest—Inches,	0·648 in.	0·695 in.	0·731 in.
" " " date, .	2d.	6th.	7th, 1861.
" " Least—Inches, .	·094	·133	·065
" " " date, .	28th.	27th.	21st, 1859.
" " Means at 7 A. M.,	·303	·340	·318
" " " 2 P. M.,	·306	·378	·349
" " " 9 P. M.,	·320	·365	·328
" " " for the month,	·310	·361	·332
Relative Humidity—Greatest—per ct.,	95 per ct.	97 per ct.	97 per ct.
" " " date,	2d.	2d.	Often.
" " Least—per ct.,	28·0	33·0	23·0
" " " date,	28th.	22d.	21st, 1859.
" " Means at 7 A.M.,	78·9	79·5	78·6
" " " 2 P.M.,	51·5	59·7	56·6
" " " 9 P.M.,	71·7	73·5	73·5
" " "for the month	67·4	70·9	69·6
Clouds—Number of clear days,* .	9	12	9·5
" " cloudy days, .	22	19	21·5
" Means of sky cov'd at 7 A.M.	60·3 per ct.	53·9 per ct.	56·8 per ct.
" " " " 2 P.M.	59·0	51·9	54·9
" " " " 9 P.M.	40·6	49·3	40·4
" " " for the month,	53·3	51·7	50·7
Rain—Amount, ...	2·663 in.	4·160 in.	2·941 in.
No. of days on which Rain fell, .	10	11	9·1
Prevailing Winds—Times in 1000,	N61°23′w·153	N73°30′w·163	N73°0′w. ·235

* Less than one-third covered at the hours of observation.

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ERRATA.

In formula 14, page 396, the *plus mark* (+) in the parenthesis should be *minus* (—), same as in formula 15; this makes D^2D in the example = 224·1 cubic feet, or 6·4 tons.

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